The Engineer

Tabular Summary of Civil Engineering Contracts, 1946

ON the pages of this Supplement there will be found tables giving some brief particulars of important civil engineering schemes upon which work was proceeding during 1946. Only those schemes for which contracts have already been awarded or are just about to be awarded have been included. The information upon which the tables have been based was obtained from numerous sources and our thanks are particularly due to those Consulting Engineers, Port Authorities, Catchment Boards, &c., who have co-operated with us.

The tables are for the most part self-explanatory. The first column of each table is headed Title of Scheme and/or Purchasing Authority. In many cases the scheme has no distinctive title and the Purchasing Authority is given only; in some the title of the scheme gives an indication of the identity of the body for which the work is being carried out, and the Purchasing Authority is not then entered. Many bodies, such as Catchment Boards and Port Authorities, have their own engineering staffs and employ no consulting engineers. In such cases the body concerned is entered in the second column as the Supervising Authority. In some cases where the chief engineer or other official of the Purchasing Authority has acted in conjunction with the consulting engineers or is himself directing the work his name is entered in italics. The entries under "Nature of Scheme and Notes" are designed to convey an impression of the nature and also the magnitude of the works, but do not necessarily mention more than the more important items. They include reference to any features of particular interest. Sub-contractors are excluded from the "Contractors" column, and only if responsible for a very substantial part of the work are contractors other than those for civil engineering works mentioned. The "Estimated Cost" is that of the complete scheme except where the alignment shows it to be that of one of the component contracts.

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		HARBOURS AND DOCKS		£		
HOME						
Royal Albert and King George V Docks	Port of London Authority	Structural repairs and renewal of sheeting, &c., Sheds Nos. 8, 23 and 28, Royal Albert Dock, and Shed No. 4 King George V Dock (damaged by enemy action)	Harland and Wolff, Ltd.	154,350	Oct., 1946	Apl., 1948 (estimated)
Various Docks	Ditto	Erection of dwelling-houses for dockmasters and police	J. Jarvis and Sons, Ltd.	47,450	June, 1946	Mar., 1947 (estimated)
Royal Victoria and Albert and King George V Docks	Ditto	Supply and delivery of 50 3-ton electric quay cranes	Stothert and Pitt, Ltd	328,750	Aug., 1945	Apl., 1947 (estimated)
Associated Portland Cement Manufacturers, Ltd.	Sir William Halcrow and Partners	Reconstruction of Swanscombe coal wharf... ...	Charles Brand and Son, Ltd.	75,000	1946	1947
Kings Lynn Docks and Railway Co., Ltd.	Rendel, Palmer and Tritton *I. J. Thatcher*	Transit sheds	J. L. Kier and Co., Ltd.	30,000	Oct., 1946	June, 1947
West Waterloo Dock ...	Mersey Docks and Harbour Board	Entrance and lock 450ft by 65ft, cill 17ft 6in L.W.S.T., monolithic concrete, granite facings, dredging river fairway 19ft below bay datum	Direct labour	1,000,000	Jan., 1937	Feb., 1948
Gladstone-Hornby Lock	Ditto	War damage repairs to lock...	Direct labour	100,000	Nov., 1945	June, 1947
South Shed, Gladstone Branch Dock, No. 1	Ditto	Rebuilding war-damaged portion of reinforced concrete treble-storey shed	Peter Lind and Co., Ltd.	291,700	June, 1946	Oct., 1947
West Side, Alexandra Dock	Ditto	Construction of dockside shed 1000ft, double storey, 600ft single storey, steel framework, brick panelling	Direct labour and Sir Wm. Arrol and Co., Ltd.	421,600	Dec., 1946	June, 1948
Electric lifts in warehouses	Ditto	Installation of thirty electric goods lifts and three electric goods-passenger lifts in dockside warehouses	Direct labour and Wm. Wadsworth and Sons, Ltd.	158,700	Nov., 1945	1949
Canada Graving Dock ...	Ditto	Electrification of pumping machinery...	Direct labour and Gwynnes Pumps, Ltd.	49,700	Oct., 1945	Dec., 1947
Riverside Station	Ditto	Reconstruction of war-damaged portions	Direct labour and Francis Morton and Co., Ltd.	33,800	Nov., 1946	Sept., 1947
Timber Storage Ground, Seaforth	Ditto	Laying out timber storage ground, including rail tracks and roadways	Sir Alfred McAlpine and Son, Ltd.	64,800	Oct., 1946	Apl., 1947
Wool Warehouse	Ditto	Reconstruction of war-damaged portions	Direct labour and Redpath, Brown and Co., Ltd.	66,500	May, 1946	Sept., 1947
Sark, Maseline Harbour, Island of Sark	Coode, Vaughan-Lee, Frank and Gwyther	Breakwater; approach road; tunnel. (This work was held up from Jan., 1941, to June, 1946, due to the German occupation of the Channel Islands)	Sir Lindsay Parkinson and Co., Ltd.	46,000	June, 1938	June, 1947

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		HARBOURS AND DOCKS (*continued*)		£		
HOME						
Regent's Canal Dock, "B" Quay, Grand Union Canal Company	Coode, Vaughan-Lee, Frank and Gwyther	Strengthening and reconstruction of quay wall...	Holst and Co., Ltd. ...	15,000	Oct., 1946	Mar., 1947
Regent's Canal Dock, N.W. Quay, Grand Union Canal Company	Ditto	Demolition and rebuilding of displaced quay wall	W. and C. French, Ltd.	40,000	Dec., 1946	Oct., 1947
FOREIGN						
Lagos Harbour, Crown Agents, Nigerian Government	Ditto	Construction of 4000 tons suction dredger... ...	Wm. Simons, Ltd. ...	540,000	Sept., 1946	Feb., 1948
	Ditto	Construction of 2500 tons suction dredger... ...	Ditto	475,000	Sept., 1946	Oct., 1947
Calcutta Port Commissioners	Rendel, Palmer and Tritton	Coal-loading plant	Fraser and Chalmers Engineering Works	97,000	Apl., 1945	June, 1948
		RAILWAYS				
HOME						
Portsmouth Harbour ...	*V. A. M. Robertson*, Chief Civil Engineer, Southern Railway	Reconstruction of station, stage 1	Dorman, Long and Co., Ltd.	32,376	Sept., 1945	—
Canterbury East	Ditto	Removal of defence works and making good ...	Cementation, Ltd. ...	10,742	Nov., 1945	—
Charing Cross Bridge ...	Ditto	Restoration of span 4, stage 2	Askham and Palin ...	12,344	July, 1946	—
	Ditto	Restoration of span 4, stage 3	Joseph Westwood and Co., Ltd.	25,156	May, 1946	—
Between Elephant and Castle and Blackfriars Junction	Ditto	Repairs to bridges Nos. 391A, 393A, 394 and 395	Ross Construction, Ltd.	10,731	May, 1945	—
Between Elephant and Castle and Blackfriars Junction	Ditto	Reconstruction of deck to bridge No. 402	Cleveland Bridge and Engineering Co., Ltd.	18,158	Feb., 1946	—
Shepton Mallet	Ditto	Repairs to bridge No. 81	W. Cowlin and Son, Ltd.	25,000	Feb., 1946	—
Vauxhall...	Ditto	Strengthening of South Lambeth bridge, No. A32	Arthur Foster	10,012	May, 1946	—
London West Division	Ditto	Repairs to various bridges	R. Robinson and Co., Ltd.	93,000	Jan., 1946	—
Southern Division... ...	Ditto	Removal of defence works	Cementation Co., Ltd.	66,747	Sept., 1946	—
London, Midland and Scottish Railway	London, Midland and Scottish Railway	Speke engine shed: Supply of precast concrete units for engine pits	Empire Stone Co., Ltd., Narborough	10,000*	—	—
	Ditto	Widnes: Supply of precast reinforced concrete engine shed roof units	The Shap Granite Co., Ltd., Shap	25,500*	—	—
	Ditto	Bow locomotive works: Demolition and repairs	Leonard Fairclough, Ltd., London	36,000*	Jan., 1945	Oct., 1946

* These figures represent the approximate amount of the contract, which may differ from the estimated total cost of the job, as in some cases further contracts may be let, or portions of the work carried out, by L.M.S. railway's staff.

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		RAILWAYS (*continued*)		£		
HOME						
London, Midland and Scottish Railway	London, Midland and Scottish Railway	Leicester: New engine shed	Messrs. Tersons, London	28,000*	Feb., 1945	Feb., 1946
	Ditto	Carlisle, Upperby: Precast concrete units for new engine shed	Empire Stone Co., Ltd., Narborough	34,500*	—	—
	Ditto	London Mornington Crescent: Partial reconstruction and reinstating damage to Carlow Street office building	J. Mowlem and Co., Ltd., London	55,000*	July, 1946	May, 1947
	Ditto	Toton: Renewal of No. 1 engine shed roof... ...	Edward Wood and Sons, Ltd., Derby	20,000*	July, 1946	Feb., 1947
	Ditto	Between Bransty and Harrington, Whitehaven Junction Line: Repairs to sea walls	Leonard Fairclough, Ltd., Adlington	13,000*	July, 1946	Jan., 1947
	Ditto	Edge Hill: Repairs and renewal of engine pits and paving, drainage, &c.	Joshua Henshaw and Sons, Liverpool	25,000*	Apl., 1946	Sept., 1946
	Ditto	Toton locomotive shed: Provision of precast concrete roof units	Trent Concrete, Ltd., Colwick, and	10,500*	—	—
			Empire Stone Co., Ltd., Narborough	60,500*	—	—
	Ditto	Speke Junction: Renewal of engine shed roof and engine pits	Holland, Hannen and Cubitts, Ltd., Liverpool	15,000*	Sept., 1945	Sept., 1946
	Ditto	Provision of steelwork for the renewal of engine shed roofs at Belle Vue, Saltley, Cricklewood and Stourton	E. C. and J. Keay, Ltd., Henley-in-Arden	11,000*	—	—
	Ditto	Manchester, Belle Vue: Renewal of engine shed roof	John Dickinson and Co. (Bolton), Ltd., Bolton	15,500*	—	Apl., 1947
	Ditto	London, Euston House: Reinstatement of office accommodation (ground and first floors) following derequisitioning	Wm. Nicholson (Leeds), Ltd., London	17,000*	Sept., 1946	Jan., 1947
	Ditto	Birmingham, New Street: Removal of twenty-five trusses from station roof	The Altitude Contracting Co., Ltd., Birmingham	66,000*	Aug., 1945	Jan., 1947
	Ditto	North London Line, Chalk Farm to Poplar: Reconstruction of superstructure of bridge No. 29	Horseley Bridge and Thomas Piggott, Ltd., Tipton	11,000*	Oct., 1946	May, 1947
	Ditto	Euston: Site clearance, foundations, drainage, &c., for accommodation for chief engineer	The Demolition and Construction Co., Ltd., London	44,000*	—	Apl., 1947
London & North-Eastern Railway	Sir William Halcrow and Partners	Thurgoland tunnel	John Cochrane and Sons, Ltd	80,000	1946	1947
London Passenger Transport Board	London Passenger Transport Board	Wood Lane: reconstruction of station and new sidings	Edmund Nuttall Sons and Co., Ltd.	202,000	May, 1946	Feb., 1948
	Ditto	Kilburn: reconstruction of bridge MR.10... ...	Arthur Foster	13,000	Mar., 1946	Nov., 1946

* These figures represent the approximate amount of the contract, which may differ from the estimated total cost of the job, as in some cases further contracts may be let, or portions of the work carried out, by L.M.S. railway's staff.

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		ROADS, BRIDGES AND TUNNELS		£		
HOME						
King George V Dock ...	Port of London Authority	Supply, delivery and erection of a new leaf, north side of bascule bridge (damaged by enemy action)	Sir Wm. Arrol and Co., Ltd.	59,250	Nov., 1945	Apl., 1947 (estimated)
Elimination of Level Crossings, Essex County Council	Rendel, Palmer and Tritton *W. J. Berry*	Railway bridges, viaducts, road widening and diversions	Part: John Cochrane and Sons, Ltd. Remainder not yet settled	57,000 163,000	Nov., 1946 —	Aug., 1947 —
Neath By-pass, Ministry of Transport	Rendel, Palmer and Tritton	Trunk road construction, bridges over river and railways, viaducts and heavy earthworks	—	—	—	—
Merthyr Slip Road, Min. of Transport	Rendel, Palmer and Tritton	Connecting link between trunk roads south and east of town	—	—	—	—
Deptford Creek Bridge ...	London County Council	Provision of temporary bridge, demolition of existing bridge, provision of new double-leaf rolling-lift bridge over Deptford Creek, span 70ft, width 70ft, steel superstructure, with concrete abutments, approach roads	Cleveland Bridge and Engineering Co., Ltd.	300,000	End 1946	Mid-1949
FOREIGN						
Baghdad Railway and Road Bridge, Iraq Government	Coode, Vaughan - Lee, Frank and Gwyther	Railway and road bridge over River Tigris; piers, abutments; approach viaducts; five bridges over in connection with railway approach viaducts	Holloway Bros., (London), Ltd.	962,000	Nov., 1945	Nov., 1948
Euphrates Railway Bridge, Iraq Government	Ditto	Railway bridge over River Euphrates; piers; abutments	Ditto	180,000	Jan., 1946	Mar., 1948
Lesser Zab Railway Bridge, Iraq Government	Ditto	Railway bridge over River Lesser Zab; piers; abutments	Ditto	130,000	Jan., 1946	Sept., 1947
		POWER STATIONS				
HOME						
Littlebrook, Kent Electric Power Co.	Sir Alexander Gibb and Partners, Merz and McLellan	Station "B"	Holloway Bros. (London), Ltd.	600,000	Feb., 1945	Feb., 1948
Earley, Central Electricity Board	Ditto	Second extension	Sir Robert McAlpine and Sons	200,000	Dec., 1944	Mar., 1946
Cliff Quay, County Borough of Ipswich	Ditto	Power station, river works, &c.	Edmund Nuttall, Sons and Co., Ltd.	1,460,000	May, 1945	May, 1948
Meaford, North - West Midlands J.E.A.	Ditto	Power station and auxiliary works	G. Percy Trentham, Ltd.	750,000	Mar., 1945	Mar., 1948

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		POWER STATIONS (*continued*)		£		
HOME						
West Ham "B," County Borough of West Ham	Sir Alexander Gibb and Partners, Merz and McLellan	Site clearance; preliminary foundation work ...	W. and C. French, Ltd. Taylor Woodrow Construction, Ltd.	22,000 100,000	June, 1946 Sept., 1946	Mar., 1947 Dec., 1947
Birkenhead, County Borough of Birkenhead	Ditto	Road and rail access work, &c.	Sir Alfred McAlpine and Son, Ltd.	60,000	May, 1946	Feb., 1947
Blackwall Point, S. Met. Elec. Light and Power Co.	Ditto	Switch house, sub-station, &c.	Holloway Bros. (London), Ltd.	80,000	Jan. 1946	Mar., 1948
Braehead, Glasgow Corporation	Ditto	Power station, river works, &c.	John Mowlem and Co. Ltd.	1,500,000	Sept., 1946	—
Poole, The Bournemouth and Poole Electricity Supply Co., Ltd.	Mott, Hay and Anderson Merz and McLellan	New power station; civil engineering works up to floor level	Sir Robert McAlpine and Sons	1,650,000	Aug., 1946	July, 1949
Kingston, Kingston-on-Thames Borough Council	Coode, Vaughan-Lee, Frank and Gwyther (in collaboration with Preece, Cardew and Rider)	Steel and concrete foundations; r.c. chimney; steel and brick building; circulating water culverts; coal wharf and storage, &c.	Charles Brand and Sons, Ltd.	850,000	Jan., 1945	Late 1947
	Ditto	Extension to power station; duplication of main building	Ditto	400,000	Jan., 1947	Early 1949
FOREIGN						
Arthur Guinness, Son, and Co., Ltd., Dublin	Sir Alexander Gibb and Partners, McLellan and Partners	New power house at St. James Gate Brewery, Dublin	McLaughlin and Harvey	200,000	Jan., 1946	June, 1947
		HYDRO-ELECTRIC WORKS				
HOME						
North of Scotland Hydro-Electric Board—Tummel Garry Project	Sir Alexander Gibb and Partners	Hydro-electric development, 148,000 kW in Perthshire	Wm. Tawse, Ltd.; Cementation Co., Ltd.; G. Wimpey and Co., Ltd.; A. M. Carmichael, Ltd.; P. and W. McLellan, Ltd.	Stage I: 2,750,000	June, 1946	1949
Ditto—Fannich Project	Sir Alexander Gibb and Partners	Hydro-electric development, 24,000 kW in Rossshire	Wm. Tawse, Ltd.; Mechans, Ltd.	1,000,000	Autumn, 1946	1949
Ditto—Loch Alsh Project	Sir William Halcrow and Partners	Hydro-electric development, Loch Alsh	Richard Costain, Ltd.; Horseley Bridge and Thomas Piggott, Ltd.	100,000	1946	1947

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		RIVER IMPROVEMENT		£		
HOME						
River Thames	Port of London Authority	Reconstruction and reinstallation of Tower Pier (damaged by enemy action)	Harland and Wolff, Ltd.	15,000	Nov., 1945	June, 1946
	Ditto	Reconstruction of Richmond Lock (damaged by enemy action)	John Cochrane and Sons, Ltd.	35,000	June, 1944	Oct., 1946
	Ditto	Replacement of s.l. "Sharebourne" and s.l. "Holebourne" by two diesel-engined launches	Groves and Guttridge, Ltd.	20,000	May, 1946	May, 1947 (estimated)
River Lee, Rammey Marsh Weir, Hackney Cut	Lee Conservancy Board	Rebuilding of weir and widening of navigation...	W. and C. French, Ltd.	12,000	June, 1946	Dec., 1946
River Lee, Brocket Park and Luton Hoo	Lee Conservancy Catchment Board	Cleaning out lakes which form part of the main river	Turney Agricultural Contractors, Ltd.	11,000	June, 1946	Jan., 1947
River Nene Catchment Board	River Nene Catchment Board	Steel piling river wall at Wisbech...	Direct labour	52,000	Nov., 1946	—
Ditto	Ditto	Reinforced concrete quay at Wisbech	Direct labour	156,000	—	1946
		WATER SUPPLY				
HOME						
Metropolitan Water Board	Metropolitan Water Board	Waterproofing the roof of Hornsey Lane service reservoir	J. B. Edwards and Co. (Whyteleafe), Ltd.	19,000	Feb., 1946	Sept., 1946
	Ditto	Interim scheme of reconstruction, Lee Bridge works	Braithwaite and Co., Engineers, Ltd.; Hathorn, Davey and Co., Ltd.; William Press and Son and direct administration	173,000	Apl., 1946	Apl., 1948
	Ditto	54in conduit, distributing reservoir to Hampton	William Moss and Sons, Ltd.	47,000	June, 1946	June, 1947
	Ditto	Reconstruction of two filter beds at Surbiton works	Direct administration	28,500	Mar., 1940	Nov., 1946
	Ditto	Hampton remodelling, primary filters, balancing and contact reservoir, conduits and mains	William Moss and Sons, Ltd.	968,950	Aug., 1937	Dec., 1947
	Ditto	Laying 3250 yards of 18in main and 550 yards of 6in main, Sidcup By-pass, Kent	J. B. Edwards and Co. (Whyteleafe), Ltd.	19,000	May, 1946	Mar., 1947
Mourne Mountains (Belfast City and District Water Commissioners)	Binnie, Deacon and Gourley	Approach road...	P. Fitzpatrick	15,000	June 12th, 1946	—

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		WATER SUPPLY (*continued*)		£		
HOME						
Claisfer - Ebbw Vale U.D.C.	Binnie, Deacon and Gourley	Approach road, intake weir, pumping station and pipe line	Dowsett Engineering Construction, Ltd.	55,000	May 17th, 1944	—
Cheshire Wells Extension, Warrington Corporation	Ditto	Boreholes at Newton Hollow...	George Stow and Co., Ltd.	45,000	May 10th, 1944	—
Birmingham Corporation Water Department	Sir William Halcrow and Partners	Dam across River Claerwen...	Edmund Nuttall, Sons and Co. (London), Ltd.	1,500,000	1946	1951
Barnsley...	Herbert Lapworth Partners	Trial bore-holes	—	12,000	Aug., 1945	Dec., 1946
Ladybower Reservoir: Derwent Valley Water Board	G. H. Hill and Sons ...	Impounding reservoir, 6000 million gallons; earthwork embankment, discharge tunnels, valve shafts, &c.	Richard Baillie ...	700,000	Jan., 1936	1947
Digley Reservoir: Huddersfield Corporation	Ditto	Impounding reservoir, earthwork embankment, discharge tunnel, valve shaft, &c.	Lehane, Mackenzie & Shand, Ltd.	800,000	Dec., 1946	1951
States Water Board, Guernsey	T. and C. Hawksley and Sir William Halcrow and Partners	St. Saviour's dam	Pauling and Co., Ltd.	250,000	1938	1947*

* Work abandoned during war

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		DRAINAGE AND SEWAGE WORKS		£		
HOME						
Dagenham Borough Council	J. D. and D. M. Watson	Sewer reconstruction and relaying	Cementation Co., Ltd.	80,000	July, 1946	1947
Bristol Aeroplane Co., Ltd.	Ditto	Oil separators and sewers	Wm. Cowlin and Son, Ltd.	18,000	Mar., 1945	May, 1946
Luton Borough Council...	Ditto	Additional sludge disposal plant and settling tanks	W. K. Porteous, Ltd.; H. C. Janes, Ltd.	10,000	Apl., 1946	June, 1947
Ceiriog R.D.C.	Ditto	Sewers and additions to sewage works for Chirk	Kottler and Heron, Ltd.	14,000	Nov., 1946	Nov., 1947
City of Peterborough ...	Ditto	Sewers, 6in to 39in, in tunnel and open trench...	Kottler and Heron, Ltd.	100,000	Nov., 1946	Nov. 1947
Audenshaw U.D.C. ...	G. B. Kershaw and Kaufman	Sewerage	C. V. Buchan and Co., Ltd.	74,000	Aug., 1946	Feb., 1948
Denton U.D.C.	Ditto	Sewerage	G. Dew and Co., Ltd.	94,000	Aug., 1946	Aug., 1948
Hazel Grove U.D.C. ...	Ditto	Sewerage	Wm. Eaves and Co., Ltd.	45,000	Dec., 1946	June, 1948
Bebington Corporation...	Ditto	Sewerage	J. McGeoch and Sons, Ltd.	203,000	Nov., 1946	May, 1949
Swinton and Pendlebury Corporation	Ditto	Sewerage and sewage disposal	Neodox, Ltd.	142,000	Dec., 1946	June, 1949
Colne Valley Sewerage Board	Sandford, Fawcett and Partners	Main sewer, 75in, tunnel section	Kinnear, Moodie and Co., Ltd.	18,000	Aug., 1945	July, 1946
	Ditto	Main sewer, 75in, tunnel section and open cut...	Ditto	104,000	Aug., 1946	Mar., 1947
	Ditto	Main sewer, 72in, tunnel section	A. Waddington and Son, Ltd.	140,000	Aug., 1946	Mar., 1948
	Ditto	Main sewer, 72in, open cut section	Ditto	140,000	Dec., 1946	Apl., 1948
	Ditto	Sewage disposal works, sedimentation tanks, &c.	John Howard and Co., Ltd.	100,000	Sept., 1946	Sept., 1947
	Ditto	Sewage disposal works, power house	G. Percy Trentham, Ltd.	55,000	June, 1946	Sept., 1947
	Ditto	Sewage disposal works, final and sludge digestion tanks, &c.	Hussey, Egan and Pickmere, Ltd.	230,000	May, 1946	Apl., 1948
	Ditto	Juniper Hill pumping station...	John Howard and Co., Ltd.	54,000	Aug., 1946	Apl., 1948
	Ditto	Pumping mains	W. and C. French, Ltd.	110,000	Jan., 1947	Jan., 1948
	Ditto	Power house machinery	National Gas and Oil Engine Co., Ltd.	120,000	—	Sept., 1947
	Ditto	Pumping station plant and machinery	Hathorn, Davey and Co., Ltd.	70,000	—	Apl., 1948
	Ditto	Sludge-disposal plant and machinery	Dorr-Oliver Co., Ltd.	165,000	—	Mar., 1948

Title of scheme and/or purchasing authority.	Consulting engineers or supervising authority.	Nature of scheme and notes.	Main contractors.	Estimated cost.	Date of starting.	Date of completion.
		DRAINAGE AND SEWAGE WORKS *(continued)*		£		
HOME						
Melford R.D.C.	Sandford, Fawcett and Partners	Roads, sewers, water mains, &c.	W. and C. French Ltd.	36,000	May, 1946	Jan., 1947
FOREIGN						
Anglo-Iranian Oil Co., Ltd.	J. D. and D. M. Watson	Design of sewers, pumping stations and outfall at Abadan	Direct labour	750,000	1943	—
		SEA DEFENCE WORKS				
HOME						
Hastings Pier, Hastings Pier Company	Coode, Vaughan - Lee, Frank and Gwyther	Reconstruction of gap; repairs to substructure; repairs to timber landing stage	Braithwaite and Co. (Engineers), Ltd., and Holloway Bros. (London), Ltd.	25,000	July, 1946	Apl., 1947
Newhaven and Seaford Sea Defence Commissioners	Sir William Halcrow and Partners	Strengthening of sea wall and other works... ...	The Demolition and Construction Co., Ltd., London	40,000	1946	1947
Llandudno Pier Co., Ltd.	Sir Cyril Kirkpatrick and Partners	Repairs to Llandudno Pier	M. A. Boswell	10,000	Nov., 1945	Oct., 1946
		MISCELLANEOUS				
FOREIGN						
Baghdad Grain Silo, Iraq Government	Coode, Vaughan - Lee, Frank and Gwyther	Grain silo of 5000 tons capacity; foundations, r.c. storage bins, steel and brick building; machinery; jetty	Holloway Bros. (London), Ltd.	200,000	Nov., 1946	July, 1948

The client or selling agent (or purchasing authority)	Consulting engineers or supervising authority	Nature of scheme and notes	Main contractors	Estimated cost	Date of starting	Date of completion
HOME						
Malton R.D.C.	Sandford, Fawcett and Partners	Roads, sewers, water mains, &c.	W. and C. French Ltd.	38,000	May, 1946	Jan., 1947
FOREIGN						
Anglo-Iberian Oil Co.	J. D. and D. M. Watson	Design of sewers, pumping stations and outfall	Direct labour	750,000	1942	—

SEA DEFENCE WORKS

HOME						
Blue Line Pier, Hastings	Cundle, Vaughan and Partners	Reconstruction of pier; repairs to substructure; repairs to timber landing stage	Brightwalton and Co. (Engineers), Ltd., and Holloway Bros. (London), Ltd.	55,000	July, 1946	April, 1947
Seaton and Seaford Urban Council	Sir William Halcrow and Partners	Strengthening of sea wall and other works	The Demolition and Construction Co., Ltd., London	40,000	1946	1947
Llandudno Pier Co.	Sir Cyril Kirkpatrick and Partners	Repairs to Llandudno Pier	M. A. Boswell	10,000	Nov., 1945	Oct., 1946

MISCELLANEOUS

FOREIGN						
Kuwait Oil Co. (Operations) Ltd.	Coode, Vaughan and Partners	Dredging to 30 ft. depth; construction of jetty, 1,000 ft. long, with 30 ft. depth alongside; storage tanks, steel and brick buildings; roads, &c.	Holloway Bros. (Lond.), Ltd.	200,000	Nov., 1946	July, 1948

A Seven-Day Journal

The I.M.E.A. and the Electricity Bill

PARTICULARS were received last week of a memorandum from the Incorporated Municipal Electrical Association addressed to the Minister of Fuel and Power on the proposed reorganisation of the electricity supply industry. This memorandum was submitted in response to the Minister's invitation to the I.M.E.A. to express its views on the best form of public ownership of the industry. Through the memorandum the Association supported the view that the whole of the electricity supply industry should be publicly owned and that a national authority should be created to control, co-ordinate and direct the industry. Such an authority suitably constituted could control and administer the generation and main transmission of electricity. The memorandum then discussed the size and number of the proposed area boards which are to be made responsible for the distribution of electricity. Balancing the advantages of a small number of area boards against the disadvantages suffered by unduly large administrative units, the Association suggested that the number of areas should not exceed thirty. The memorandum proceeded to elaborate the view that a successful distribution service must depend upon the intimate personal contact with the consumer that can only be achieved by a medium-sized administrative unit. To this end the memorandum recommended that any legislation which provides for the establishment of area boards should place upon these boards an obligation to divide the areas into a suitable number of districts, delegating to each district unit sufficient powers to enable it to function efficiently. In an organisation of this kind the engineer and manager of each district would be responsible to a district committee composed of representatives of local authorities in the district, together with representatives nominated by recognised industrial and labour organisations. Such an arrangement comprising a national authority and area boards with administrative powers delegated to district units would remove the necessity for creating consultative councils alongside the area boards and would, in the view of the I.M.E.A., meet the needs of the whole community with the minimum of dislocation.

Proposed International Exhibition, 1951

LAST November the Council of the Royal Society of Arts expressed some concern over the present position regarding the proposed International Exhibition in 1951, and felt that the Government had begun to entertain doubts regarding the intention to organise such an exhibition as suggested by the Ramsden Committee. Feeling that such a change of policy was to be deplored, the Council appointed a small committee to make approaches to the Government on the matter, and more recently it was decided to convene a conference to assess public opinion regarding the proposed exhibition. This conference was held at the Royal Society of Arts on Thursday of last week, and there was a large attendance representative of scientific, cultural, commercial and industrial organisations. Viscount Bennett, President of the Society, was in the chair, and Viscount Samuel opened the discussion by outlining the main purposes which the Society had in mind in recommending that an International Exhibition should be held. He emphasised that such an exhibition would have a cultural as well as a commercial value, that it could bring many overseas visitors to this country, and that it would give a stimulus to international trade and to our own trade in particular. Acknowledging the difficulties concerning the site, materials, accommodation and transport which presented themselves, Viscount Samuel suggested that a similar situation had been faced in connection with the Great Exhibition of 1851, and he felt certain that, as then, public opinion could supply much of the driving force needed. Three questions which he submitted to the conference were whether an International Exhibition was desirable, where it should be held and when it should take place. The several speakers who followed Viscount Samuel indicated that opinion was fairly evenly divided as to the desirability of proceeding at present with the organisation of an exhibition. Support for the exhibition in principle was expressed by representatives of many organisations; there were some who favoured Hyde Park as a site, and several others who thought that other sites—such as the south bank of the Thames—would be much more suitable. Doubts were expressed, however, as to whether building materials and labour were likely to be in sufficient supply to permit the erection of an exhibition by 1951.

The Engineering Advisory Council

IN a Seven Day Journal note on December 20th last, we recorded the Minister of Supply's decision to set up an Engineering Advisory Council, the purpose of which would be to provide a means of consultation with employers and workers on matters of general concern to the engineering industry. Matters normally handled by the joint organisations of employers and trade unions in connection with wages and conditions of employment, the Minister stated, would be excluded from the activities of the Council. It was further explained that, for the purposes of the Council, the engineering industries would comprise mechanical, electrical and radio engineering, but not shipbuilding or the iron and steel industry which fell within the purview of the Iron and Steel Board. In the House of Commoms on Monday last, the Minister announced that the following had been appointed members of the Engineering Advisory Council: on the employers' side, Mr. G. Darnley-Smith, of Bush Radio, Ltd.; Viscount Davidson, of the Channel Steel Co., Ltd.; Mr. C. K. F. Hague, of Babcock and Wilcox, Ltd.; Mr. G. S. Maginness, of the Churchill Machine Tool Co., Ltd., and a member of the National Joint Advisory Council; Sir Robert Micklem, of Vickers-Armstrongs, Ltd.; Sir Harry Railing, of the General Electric Co., Ltd.; Colonel H. Riggall, of Ruston and Hornsby, Ltd.; Sir Alexander Ramsay, of the Engineering and Allied Employers' National Federation; Sir William Rootes, of Rootes, Ltd.; Mr. Mark H. Taylor, of Taylor, Taylor and Hobson, Ltd.; and Mr. W. R. Verdon Smith, of the Bristol Aeroplane Co., Ltd.; on the trade union side, Mr. W. G. Beard, Mr. H. G. Brotherton, Mr. F. Foulkes, Mr. J. Gardner, Mr. H. N. Harrison, Sir Mark Hodgson, Mr. Gavin Martin, Mr. H. R. Nicholas, Mr. J. R. Scott, Mr. J. W. Stephenson, and Mr. J. Tanner. The Minister of Supply will act as chairman of the Council, and the secretary is Mr. W. G. Downey, Engineering Industries Division of the Ministry. The first meeting of the Council was arranged to take place on Wednesday morning last, February 12th.

The Late Ir Wouter Cool

THOSE of our readers who know Holland will learn with regret of the death of Ir Wouter Cool, who, for fifteen years up to the end of December last, was General Secretary of the Koninklijk Instituut Van Ingenieurs, and Chief Editor of the Instituut's weekly journal *De Ingenieur*. We have just learned of his death on Thursday, January 30th, at the Hague, about a month after his recent retirement. Wouter Cool gained his early engineering experience from 1898 to 1914 in the service of the Rotterdam Harbour Authority, where he worked under that pioneer director and engineer, the late Ir G. J. De Jongh. In 1914 he went out to the Dutch Indies, and about a year after became general adviser on the harbour works and the improvements which were then being carried out. He was made executive chief of the Harbour Works Department. In 1921 he was appointed chief engineer of the Netherlands Indies Railways, and he also occupied the position of Principal of the Technical High School at Bandoeng. He was, too, the corresponding member of Council of the Instituut Van Ingenieurs in the Hague. He always took a keen interest in all international movements and was general secretary of the International Engineers Congress which took place in Batavia in 1919. He was in later years a prominent figure at the International Shipping Conferences and the World Power Conferences. His great work for the Koninklijk Instituut Van Ingenieurs of Prinsessgracht 23, the Hague, began in January, 1932, when he succeeded the late Ir R. A. van Sandick, as General Secretary and Chief Editor of *De Ingenieur*. He made many friends, and was well known to members of other technical institutions. He did much to prepare for the Centenary Celebrations of the Instituut, and he personally received the many deputations on that occasion. He will long be remembered for his outstanding work, his charm, and his help in all matters concerning his country and his institution. On January 1st, he was succeeded by Ir H. Sangster, who worked with him for many years.

F.B.I. Regional Research Conference

THE Federation of British Industries is to sponsor a series of regional conferences on industry and research, and the first will be held at Birmingham on Tuesday, March 25th. The principal speakers will be Sir Edward Appleton, F.R.S., Secretary of the Department of Scientific and Industrial Research, Sir William Larke, Chairman of the F.B.I. Industrial Research Committee, and Sir Peter Bennett, M.P., Chairman of the F.B.I. Midland Regional Council. The general subject to be discussed will be the application of science by industry, and the part research can play in promoting industrial efficiency, exports, and a higher standard of living, with special reference to industrial problems in the Birmingham area. Special attention will also be given to the smaller manufacturing concern which cannot afford the cost of a research department, and to the research organisations and facilities which could serve it. The conference will be held at the Queen's Hotel, and admission will be free to all interested. Further information may be obtained from the F.B.I. Industrial Research Secretariat, at 21, Tothill Street, Westminster, London, S.W.1.

Advisory Council on Scientific Policy

ON this page of our last issue reference was made to the Government's decision to set up an Advisory Council on Scientific Policy to advise the Lord President of the Council in the exercise of his responsibility for the formulation and execution of scientific policy. Sir Henry Tizard is to serve as chairman of this Council, and the names of the other members were announced at the beginning of this week. They are:—Sir Edward Appleton, F.R.S., Department of Scientific and Industrial Research; Sir Alan Barlow, Second Secretary to the Treasury; Sir Howard Florey, F.R.S., Professor of Pathology, Oxford University; Sir John Fryer, the Agricultural Research Council; Sir Claude Gibb, F.R.S., M.I. Mech. E., of C. A. Parsons and Co., Ltd.; Sir Edward Mellanby, F.R.S., Secretary of the Medical Research Council; Sir Edward Salisbury, F.R.S., Secretary of the Royal Society; Sir Ewart Smith, M.I. Mech. E., Imperial Chemical Industries, Ltd.; Sir Reginald Stradling, F.R.S., M. Inst. C.E., Chief Scientific Adviser, Ministry of Works; Professor A. R. Todd, F.R.S., Professor of Organic Chemistry, Cambridge University; Dr. A. E. Trueman, F.R.S., deputy chairman of the University Grants Committee; and Professor S. Zuckerman, F.R.S., Professor of Anatomy, Birmingham University.

Laying Up the American Navy

(By Our Naval Correspondent)

THERE is no denying the fact that when the war in the Pacific came to its unexpectedly abrupt end, the United States of America possessed materially the strongest naval force in the world, which was still being augmented day by day by the output of the shipyards. With the war over, the United States naval authorities had to decide what was to be done with the enormous collection of warships which had suddenly become redundant. They were reluctant to scrap what amounted in most cases to almost brand-new material, certainly until such negotiation. Only by wholesale laying up could the manpower situation be met in the face of demands for the speediest demobilisation. The United States naval authorities went further than this, and demanded that means should be found of laying up warships which would guarantee no deterioration of material and which would be easily removable so that the ships could be brought to full operational efficiency in the minimum of time.

These were the factors which led to the inception of what was officially designated "Operation Zipper." "Operation Zipper," time as the United States was assured that a lasting peace had been achieved—an assurance which they are still far from feeling. They had seen the drawbacks of the ordinary old laying-up technique as was practised in 1919, for they had been frankly disappointed at the condition of the old flush-decked destroyers which were pulled out to fulfil the first of the Anglo-British reciprocal agreements and which were called upon suddenly to face the emergency of 1940.

It was argued therefore that the United States must find means of laying up warships, not only in order that they should be temporarily saved from the shipbreakers, but in order that the laid-up ships should form a "fleet in being" during the coming years of which has now been in progress for some months, but which is still far from complete, provides for the laying up in an entirely new manner of a fleet larger than that possessed by the United States at the beginning of the war, and ranging through all the categories of naval craft from battleships and aircraft carriers to submarines and landing craft. The ships to be laid up are being assigned to two fleets—the Sixteenth Fleet on the Atlantic coast and the Nineteenth Fleet on the Pacific coast.

"Operation Zipper"

When "Operation Zipper" is complete nearly 2000 vessels will have been scientifically laid up. Of these, 680 will be what are classed as "combatant vessels" and will consist of the following :—

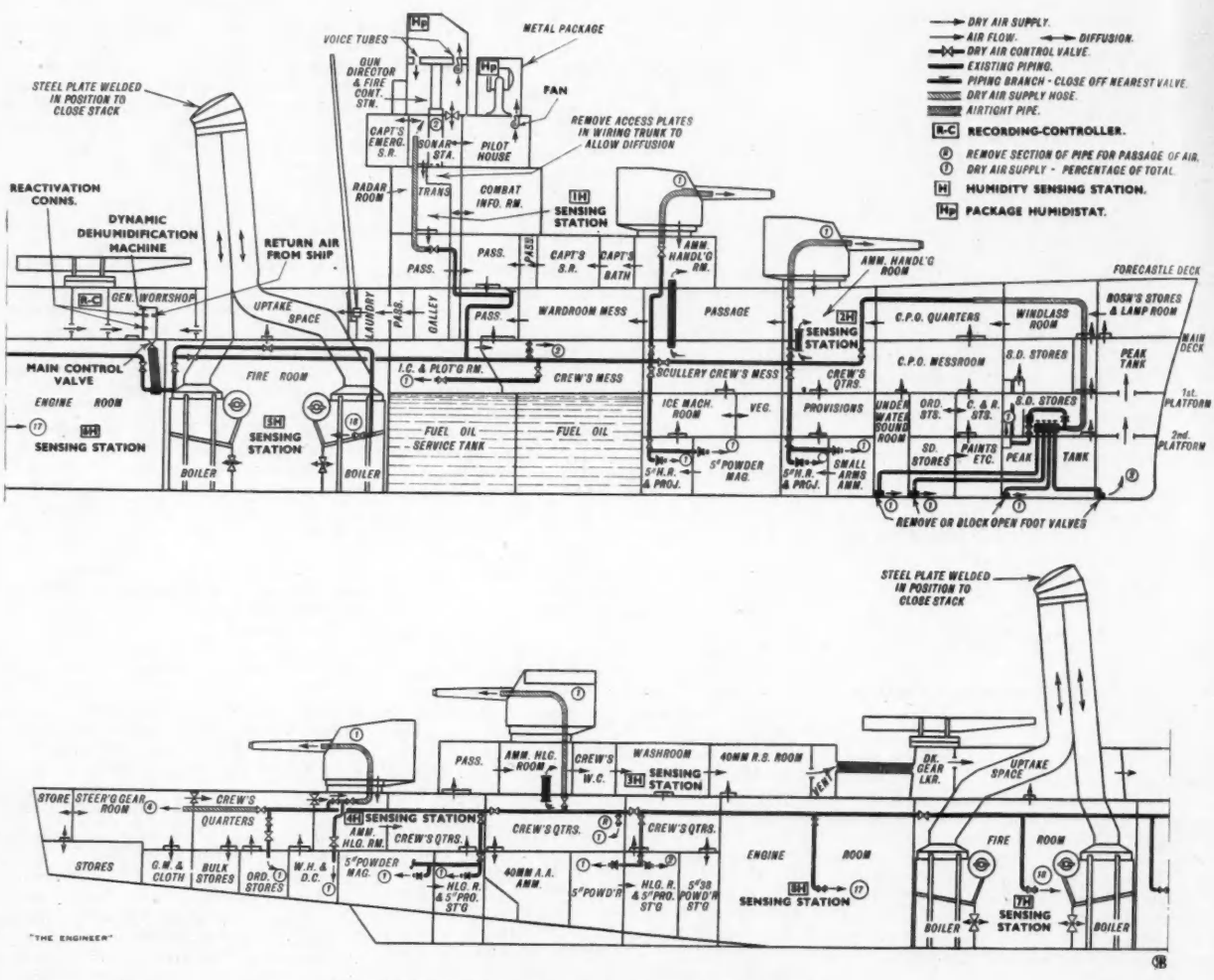
10 battleships.
3 battle-cruisers of the "Guam" class.
10 "Fleet" aircraft carriers.
20 "Light Fleet" aircraft carriers of the "Essex" class.
40 "Escort" aircraft carriers.
16 heavy cruisers.
20 light cruisers.
153 destroyers.
250 escort destroyers.
55 submarines.

The other vessels to be laid up by the United States Navy comprise :—

208 auxiliary ships of various types.
541 landing craft.
125 minesweepers.
173 "district" (local defence) craft.
72 patrol vessels.
93 repair ships and tenders.
55 accommodation ships.
44 tugs.

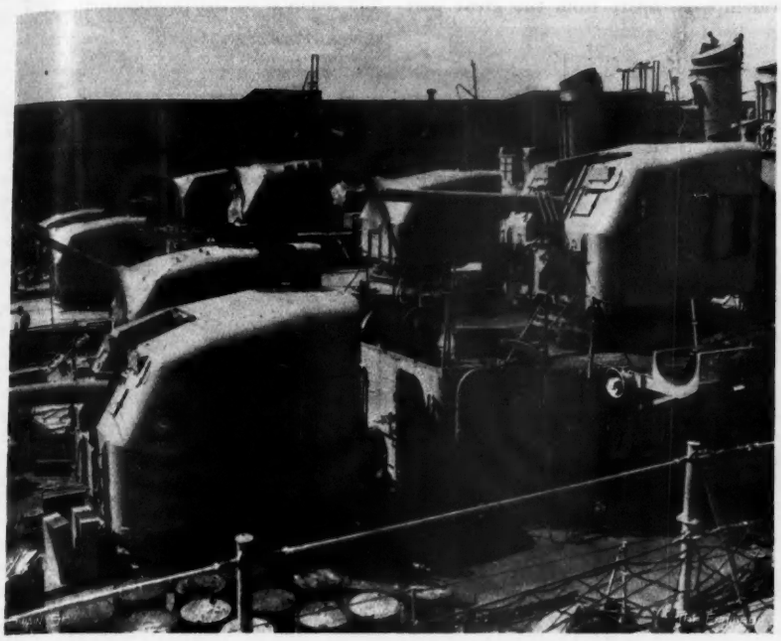
The figures are almost staggering, and the work of laying up this great number of vessels is immense. It has been calculated, however, that the cost of maintaining this great laid-up navy will amount to less than 1 per cent of the original cost of the vessels. Moreover, the work of maintenance on the ships will absorb less than 5 per cent of the present allowed manpower of the American Navy.

The whole of this inactivation programme is being carried out on the basis that it will be possible at any time to put the ships into full commission in from ten to thirty days, depending upon the class of ship. Considerable attention has also been paid to the realisation that if and when the ships are put into full commission it will probably have to



ARRANGEMENT OF DEHUMIDIFYING EQUIPMENT

be done in a hurry and largely by inexperienced crews. The whole process of laying up has therefore been worked out on what may be termed a "foolproof" basis. In each group of laid-up ships there is one ship which acts as "maintenance ship" to the group.



"INACTIVATION" IN PROGRESS AT THE NAVY YARD, CHARLESTON

The maintenance personnel for the group live in this ship. In the "maintenance ship" of the group there is a "preservation office" containing the detailed history of the laying-up process, as applied to each ship in the group, the position of all stores not on board, and step-by-step instructions for the "activation" of each ship. In the ships, too, each item of machinery and equipment has attached to it a label on which are given precise instructions for bringing the item in question to a state of operating efficiency. In the case of portions of equipment where the laying-up process has necessitated the removal of a component, the label contains the information of where the component is to be found. A case in which this technique is adopted is in the electric hand lamps used for emergency lighting, where the batteries have to be removed for care and maintenance routine to be carried out.

One of the principles of the American laying-up organisation is that, as far as possible, all the stores required by the ship when in full commission shall remain on board. This, however, cannot be applied to perishable stores, equipment likely to deteriorate through lack of use, and ammunition. Even here, however, the principle has been followed to the extent of placing all the disembarked stores in warehouses alongside the berths occupied by the ships to which the stores belong. Here the Americans have been assisted by the possession of large harbours which have little or no use in peacetime, and where the water is almost fresh, so that marine growth on the bottoms of laid-up ships is reduced to the minimum. It is reckoned that on the average it will be sufficient to dock the laid-up ships about once in six years, as a result of coating them with hot plastic and berthing them in near-fresh water.

INTERNAL PRESERVATION

The process of scientific preservation of ships adopted by the Americans may be divided into two stages—that concerned with the internal structure, fittings and machinery, and that concerned with fittings which would normally be more or less open to the weather.

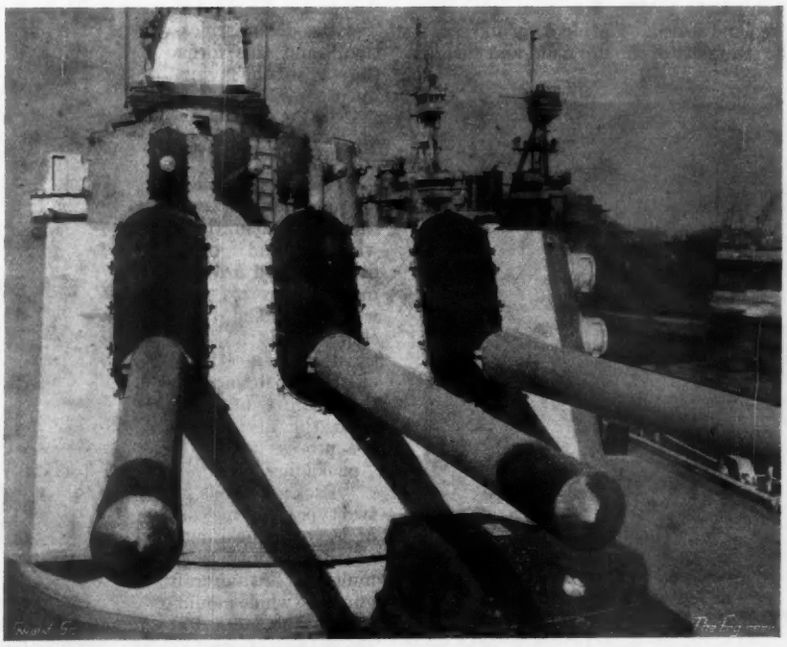
By far the most important part of the internal preservation is its conversion into a number of air-conditioned "zones," in each of which the humidity of the atmosphere is kept far below that of the outside air.

Deterioration, corrosion and oxidation are in almost every case accelerated by humidity, and there is a degree of humidity at which these processes are reduced almost to nil. By a series of experiments the Americans have determined this degree of humidity to be in the nature of 30 per cent, and it is to this degree of humidity that the air within their laid-up warships is reduced. It is claimed that at that degree of humidity oxidation is so small that a crew will not even have to polish the bright work, although this is not coated with grease or other preservative. The principle is, in fact, that the conditioned dry air takes the place of the heavy grease and preservative coatings which were hitherto considered necessary.

Some preservative coating is, however, used. All machinery, &c., is opened up and "fogged" with a thin film of gelatinous grease. This film is so thin that there is no necessity to remove it before closing up and starting the machinery.

For the purpose of dehumidifying the atmosphere in the ship, the vessel is divided into "zones." Each zone is, in effect, a sealed compartment served by one dehumidifying machine. Within the zone all hatches and doors are open, so that the various spaces of the ship's structure become one common compartment. The zone is sealed from the outside air by the sealing of all ventilation and other intakes with plastic. The zone is, however, accessible, and, in fact, the maintenance personnel carry out frequent "rounds" to ensure that all is in order and to take the readings of the humidity in the atmosphere of the various zones. These are recorded by special instruments which work on the barograph principle and are placed in the zones in positions remote from the dehumidifying machines, so that it may be assumed that the worst conditions in the zone are those which are recorded.

In large ships the danger of rapid flooding in case of a leak is minimised by dividing the zone into vertical components between bulkheads, but these components all remain part of the zone, since they are either common at their upper ends or are connected by trunking. A zone will, of course, contain every compartment in that section of the ship which it is possible to seal from the outside atmosphere. Thus gun turrets and even guns themselves form part of their appropriate dehumidified zone by the sealing of their tampions and the opening of their breech mechanisms.

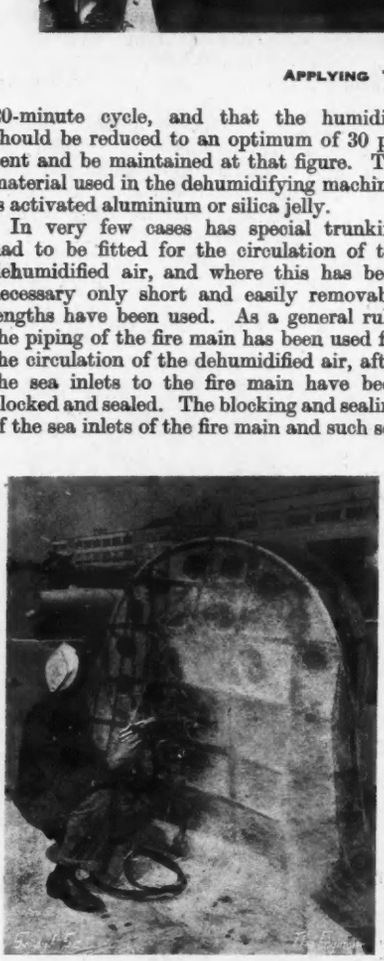


SEALED GUN MOUNTINGS

The lay-out of the zones and the dehumidifying arrangements in a ship require an

intimate knowledge of the ship and a good deal of ingenuity. The dehumidifying machines used are of two types, the larger with a capacity of 500 cubic feet per minute and the smaller with a capacity of 100 cubic feet per minute. The systems are worked out on the principle that the atmosphere in a zone shall be changed completely in a 20-minute cycle, and that the humidity should be reduced to an optimum of 30 per cent and be maintained at that figure. The material used in the dehumidifying machines is activated aluminium or silica jelly.

In very few cases has special trunking had to be fitted for the circulation of the dehumidified air, and where this has been necessary only short and easily removable lengths have been used. As a general rule, the piping of the fire main has been used for the circulation of the dehumidified air, after the sea inlets to the fire main have been blocked and sealed. The blocking and sealing of the sea inlets of the fire main and such sea valves as the circulating water inlets is done in such a way that they can be freed from inside the ship, so that docking will not be necessary when bringing the ship forward into operational use.



SPRAYING PLASTIC ON TAPE NETWORK

At first sight the use of the fire main for the circulation of the dehumidified air would seem a strange choice, but this system has been used because it enables the dry air to be discharged in the remote portions of compartments, through the normal fire main suction pipes, and so eliminates the danger of pockets of humid air.

One of the advantages of the dehumidifying of the atmosphere within the laid-up warships is, apart from the great part which it plays in the preservation of fittings and structure, the fact that it enables large quantities of stores to remain in place and in readiness for the rapid commissioning of the ship in case of need. Thus, even the mattresses on the bunks in the living quarters are left in place and they remain perfectly dry and "sweet."

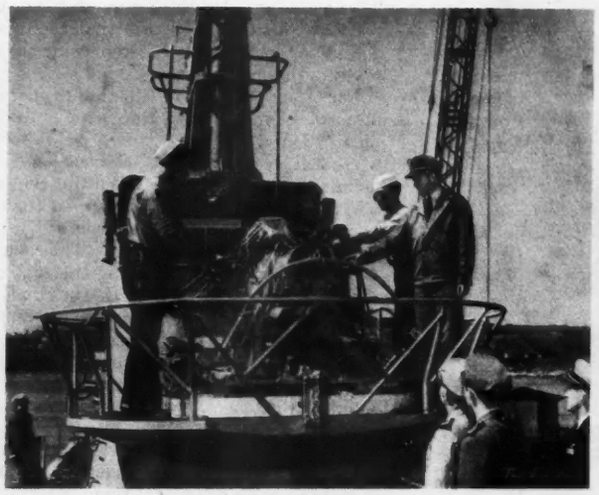
In the nomenclature of the American laying-up organisation the machine-driven dehumidification of the air within the sealed zones of a ship's hull is referred to as "dynamic dehumidification." There is also "static dehumidification," and this forms the stage of the laying-up process.

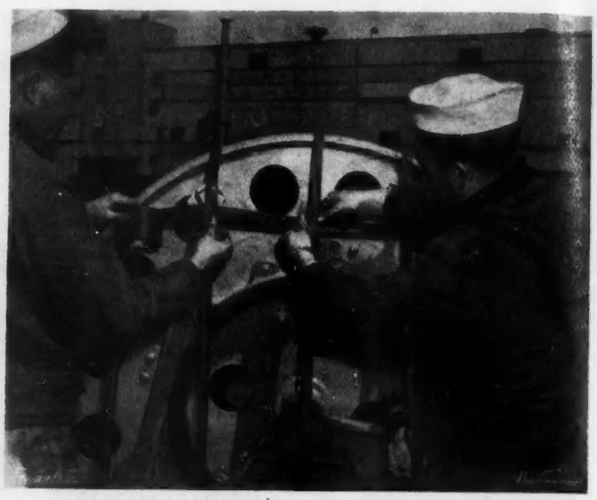
Static Dehumidification

"Static dehumidification" applies to all the gun mountings, winches and other fittings which are normally open to the weather. The first step towards the "static dehumidification" of these fittings is the sealing of them from the atmosphere—a process known as "packaging."

"Packaging" is of two types. In the case of large fittings, such as the mountings of multiple anti-aircraft guns, the whole mounting may be encased in a prefabricated dome-shaped hut of sheet metal. Another form of "packaging" is that done with a flexible plastic, and this method is used for the great majority of fittings as well as for the sealing of ventilation intakes, gun tampions and the like.

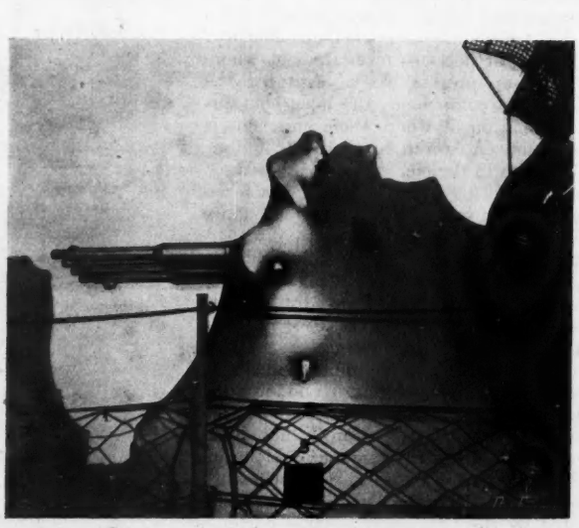
The system of plastic "packaging" is very interesting. It was evolved in the first instance as weather protection for stores and spare parts carried by the ships of the Fleet Train for transfer to the combatant ships in the war zone in the Pacific. The first requirements of plastic "packaging" are that it should be quick and easy to remove, and that it should not adhere to the metal surfaces which it has to protect. Were it to do so, the removal of the plastic would be a long and complicated task, particularly where complicated mechanisms, such as the breech mechanisms of automatic guns, is concerned.





APPLYING TAPE NETWORK TO A 40-MM GUN MOUNTING AND TO A WINCH

The first step in the plastic "packaging" of an item of equipment on the weather deck of a warship is the fitting of a network of Scotch tape over the whole of the article to be "packaged." When this network is in place, with a mesh of about 8in square, a plastic is sprayed on. This adheres to the Scotch tape and forms a sort of cobweb. Additional coatings of plastic are sprayed on to this cobweb until the whole of the gun mounting, winch or whatever it may be is shrouded in a coating of plastic over an eighth of an inch thick and capable of bearing the weight of a man. This strength is necessary in order to bear the weight of a heavy fall of snow.



"PACKAGED" GUN MOUNTING

When this airtight "package" is complete, apertures are cut in it, which are left open for fourteen days to ensure that any gas formed within the "package" is fully

dispersed. Then the air within the "package" is dehumidified by a portable dehumidifying machine, after which a supply of dehumidifying agent is placed within the "package" to carry on the work of "static dehumidification." Silica jelly is used for this purpose, and a two-drum winch will require about 30 lb of this substance to be placed within the "package." Instruments for reading the humidity of the air within the "package" are placed within the plastic, which is provided with a small glass window through which the instruments can be read. Finally, the whole of the "package" is coated with aluminium paint as a protection against the infra-red rays of the sun.

Yet another form of "packaging" is used in the case of small fittings, such as bulkhead switches. This is known as "liquid envelope," and consists of a spray of a plastic material called Vinylite. It is nothing like as strong as the other packaging plastic, which is a product evolved by the United States Bureau of Naval Ordnance, but it is excellent for small work and has the advantage that the percentage shrinkage is only about 1·5 per cent instead of some 15 per cent in the case of the heavier packaging plastic.

The wooden flight decks of aircraft carriers are specially treated to preserve them against the weather when laying up these vessels. Here the first step is the covering of the arrester gear slots with long canvas strips. Then the entire deck is coated with a sprayed compound of creosote and sulphur. This compound is a strong wood preservative. As this preservative compound is sprayed on the deck and while it is still sticky cheese cloth is laid by rolling rolls of the material along the deck and laying long strips of the cloth. This cheese cloth serves not only as a binding material for the wood preservative compound and the next layer, which is a chemical oil compound, but it forms a quick and easy way of removing the upper layers from the deck, since it can be ripped off in long strips when the ship is replaced in commission.

When the chemical oil compound has been applied the deck is covered with another layer of cloth. This time a 10-oz duck is used. Finally the entire deck is treated to two coats of aluminium paint.

"Operation Zipper" is certainly a vast and complicated undertaking. Its value can only be assessed in the light of the history of the next twenty years, but in any case the great laid-up fleets of the United States can be regarded as a form of insurance.

An interesting side light on this scientific method of laying up warships is that it was planned before even the war in Europe had come to an end. It was, in fact, planned as long ago as 1943, and while the war was still in progress large-scale experiments were carried out with the big naval cargo transport "North Star."

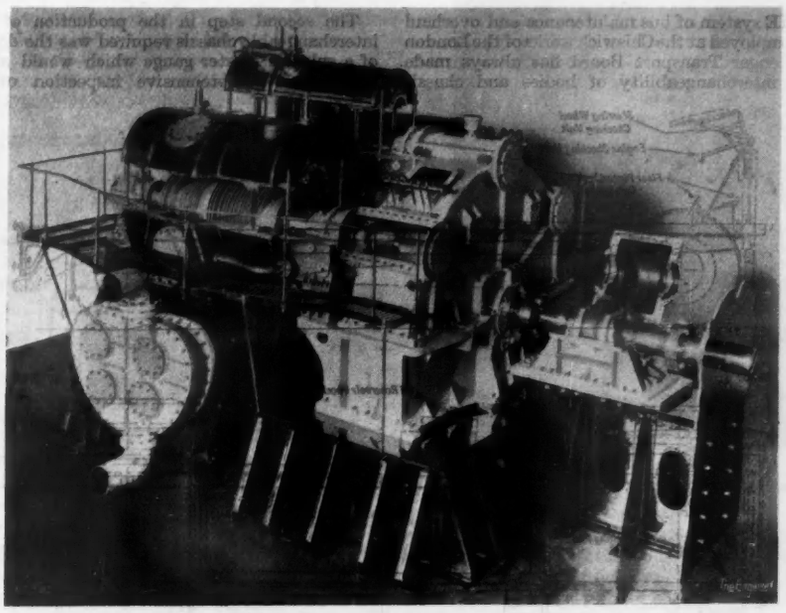
APPLYING PRESERVATIVE TO A CARRIER DECK

Worshipful Company of Shipwrights' Exhibition

No. III—(*Continued from page 143, February 7th*)

PARSONS MARINE STEAM TURBINE COMPANY, LTD.

On the stand of the Parsons Marine Steam Turbine Company, Ltd., of Turbinia Works, Wallsend-on-Tyne, there was shown the scale model of one unit of a twin-screw installation of Parsons single-reduction marine geared turbine machinery, illustrated herewith. It comprises one high-pressure turbine, one intermediate-pressure turbine with the high-pressure astern turbine incorporated, and one low-pressure turbine with the low-pressure astern turbine incorporated. The double helical gearing connecting with the propeller shaft was to be seen in the model, with its lubricating arrangements. The thrust block was also shown, and the condenser below the turbines. The turbine covers were raised to show the blading. The high-pressure and the intermediate-pressure turbines are of the all-reaction type and are furnished with end-tightened blades, in order to obtain the highest economy. The h.p. astern turbine is of the impulse type and the l.p. astern turbine of the impulse-reaction type. The relative speeds of the turbines and the propeller when developing a power of 3500 s.h.p. are: h.p., 2950 r.p.m.; i.p., 2950 r.p.m.; and l.p., 2400 r.p.m., the propeller running at 153·5 r.p.m., giving a ratio of reduction of 19·25 for the h.p. and l.p. pinions and 15·7 for the l.p. pinion.



MODEL OF ONE UNIT OF TWIN-SCREW 3500 S.H.P. GEARED TURBINE INSTALLATION

Similar turbine arrangements, but with double-reduction gearing, are being installed in post-war passenger and cargo vessels. The first installation of this kind since the war by Parsons will be installed in the Silver Line ship "Silverbriar," now under construction at the Sunderland yard of Joseph L. Thompson and Sons, Ltd., of Sunderland, a model of which appeared on Messrs. Thompson's stand. Steam will be raised in Foster Wheeler boilers, built by Richardsons, Westgarth and Co., Ltd., of West Hartlepool.

(*To be continued*)

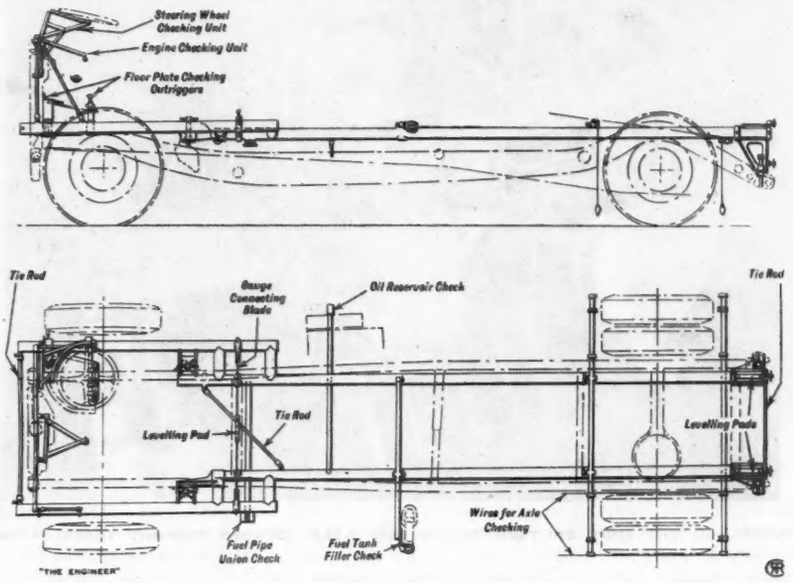
THE DUCTILITY OF COPPER.—An unusual example of the ductility of copper was cited by Mr. B. H. Thorp, mechanical engineer to the Copper Development Association, in a lecture to members of the Engineering Society at Leeds University on January 30th, in describing a process used during the war to produce honeycomb radiator and oil cooler tubes. He said that a piece of copper rod, about 0·4in diameter and about ½in long, was placed in a die and a punch was driven into it, forcing the copper out through the die in the form of a tube about ⅜in diameter up to 14in long, and with a wall about 6/1000in thick. The whole operation took rather less than 1 sec. to complete, and was carried out with the copper at room temperature and without any preheating.

A Gauge for Interchangeable Bus Chassis Manufacture

THE system of bus maintenance and overhaul employed at the Chiswick works of the London Passenger Transport Board has always made the interchangeability of bodies and chassis particularly desirable. As a result of the experience gained in the organisation of aircraft construction during the war, the company has now introduced a system whereby master jigs are used in the building of chassis and bodies to ensure complete interchangeability of chassis in the future. In preparing the new master jig designs a standard of tolerances was first laid down to set a limit on the amount of variation acceptable. Provision was then made in the design of chassis and bodies to facilitate satisfactory assembly.

Line sketches were made of the completed body and the chassis, indicating the dimensions and features which directly reacted upon assembly and mating. All dimensions which were subsequently used had plus or minus limits imposed. These limits were then interpreted as extremes within which components could be built. In determining the limits it was necessary to make the tolerances as large as possible in the interests of production and if they were found to be undesirably tight, detail design was reconsidered to permit relaxation of tolerances.

The second step in the production of the interchangeable chassis required was the design of a suitable master gauge which would allow rapid and comprehensive inspection of all the major points of location between chassis and body. The gauge which was evolved for this purpose is shown in the accompanying illustrations and drawings. Its design is such that where suitable lifting gear is available the jig can be elevated and lowered on the chassis as a complete unit. If there is no lifting gear, the various component parts, which are sufficiently light to permit man-handling, can be applied in sections and built up on the chassis.



GAUGE APPLIED TO A CHASSIS

The gauge is of tubular construction, and is fitted with master datum points, from which all vital points on a chassis can readily be checked. It rests on the two front and the two rear body brackets only, taking its location from the front and rear body mounting dowels. With the chassis jacked to read level at three points, both the chassis and the gauge remain in a state of repose throughout the check.

The gauge is designed to clear all parts of the chassis, with sufficient margin to ensure that it may be applied to a chassis even though the latter might vary from the correct dimensions. Thus even when one or two dimensions of the chassis are incorrect, it is still possible to apply the gauge and complete the inspection, the incorrect dimensions being subsequently rectified.

The main points which are checked by the application of the gauge are as follows:—The centres, diagonals and level plane of the four main body-mounting brackets and dowel holes; the position of the radiator in three planes; the position of the steering wheel in three planes; the vertical alignment of the engine; the position and setting of the driving cabin floor plate; the position of the fuel pipe unions; the position of the oil reservoir; the position of the fuel tank filler; and the alignment and lateral position of the rear axle.

In the first photograph reproduced below, the outriggers can be seen extending from the forward section of the offside main tube of the gauge, over the driving cab floor plate. These outriggers carry two bored masking plates, through which pass five shouldered gauging pins. These pins are screwed into tapped holes in the floor and in conjunction with the masking plates serve three main checking purposes. First, the shoulders formed above their screwed ends have to clear the edge of the raised central portion of the floor plate. Secondly their stems have to be central in the masking plate holes within set limits. Thirdly, steps formed about half way along their length have to be within a limited distance of the top of the masking plate. These three checks ensure correct mating of the cab on the body with the floor plate of the chassis on assembly. The background of the same illustration shows the tubular gauge assembly carrying the masking plate used for checking the position of the radiator. A rearwards extension of this assembly carries a gauge which registers over the top of the engine cover.

The second engraving illustrates the method which has been devised for checking the overall width of the vehicle and ensuring the correct clearance in the body wheel arches. Two of the gauge cross members extending over the full width of the chassis and wheels carry a number of fixed datum points. To check the squareness of the axle relatively to the centre line of the vehicle, four plumb lines are used. These plumb lines are dropped from notched plates on the cross member and the distances are measured between each of the lines and the nearest point on the adjoining tyres. For true squareness of the axle these distances must fall within a certain preset limit.

In order to check the lateral position of the axle in the chassis, four wires are rigidly fixed longitudinally between a pair of pins at each end of the two cross members. The distance between the wires and the tyres is then measured to ensure that it lies within set limits.

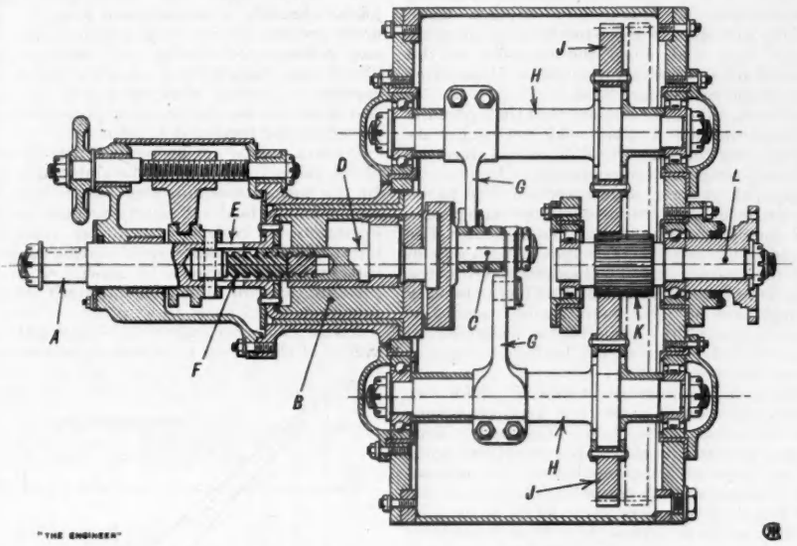
GAUGING EQUIPMENT FOR DRIVING CAB FLOOR

ARRANGEMENT FOR AXLE CHECKING

An Infinitely Variable Speed Gear

WE recently inspected a prototype model of an interesting infinitely variable speed gear, which has been developed by McEwan and Neave, Ltd., Milngavie Road, Bearsden, Glasgow. This gear was designed to transmit 7 h.p. at 500 r.p.m. input, the speed of the output or driven shaft being infinitely variable from zero up to 1000 r.p.m.

The principle upon which the gear works can be followed with reference to the drawing and photographs we reproduce. Initial drive is transmitted from the shaft A to a rotating member B which actuates a variable-throw crank C within the main housing. This crank is carried by a spindle D mounted excentrically in the rotating member. By means of two sleeves E and F the spindle centre line is adjustable within the rotating member and its setting decides the length of throw of the crank. For setting purposes, axial movement of the sleeve E is effected through a hand wheel, and this movement increases or decreases the degree of excentricity of the spindle D in the rotating member B.

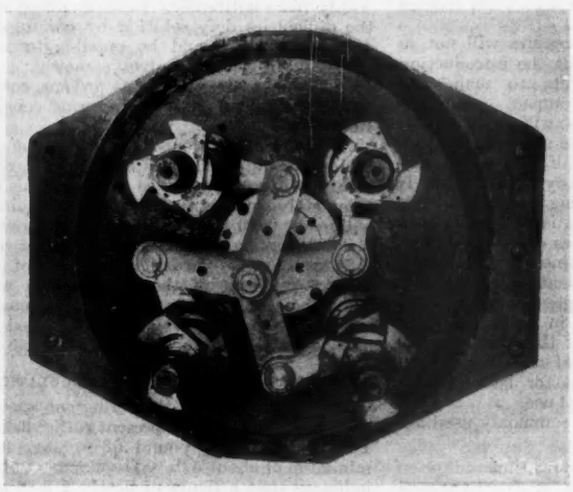


WORKING ARRANGEMENT OF VARIABLE SPEED GEAR

Mounted on the crank are four connecting-rods G, which are coupled by links at their outer ends to rocking shafts H. These shafts extend the full width of the gear housing and are carried in roller bearings at each end. At the ends of the shafts, opposite to the links, are one-way drive roller or clutch mechanisms, which drive the gear wheels J in one direction only, and freely rotate when not under load. Each of these gear wheels meshes with a common, centrally disposed pinion K keyed to the output shaft L.

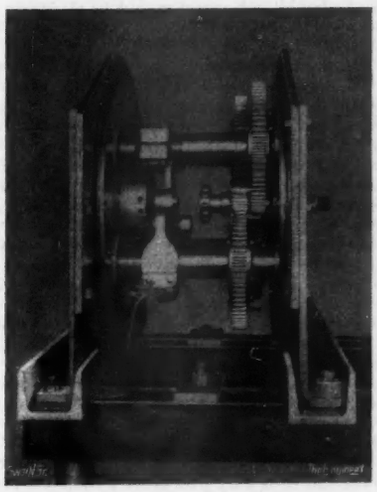
It will be appreciated that, in operation, drive imparted by the throw of the crank is transmitted through the connecting-rods, links, rocking shafts and one-way drive gear wheels, each in turn to the output shaft pinion.

The method by which speed variation of the output shaft is obtained is relatively simple. The speed of reciprocation of the connecting-rods, and therefore the driving momentum between the rocking shafts and gear wheels J, is constant. The variable factor is the actual length of "driving" or "working" arc imparted to the gear wheels, and this is altered by the lengthening or shortening of the connecting-rod stroke. It will be seen that with the maximum length of gear working arc the number of revolutions imparted to the pinion is greatest, whilst, as the length of arc is reduced, the number of pinion revolutions is correspondingly decreased in the same given time. As there are four overlapping driving gears turning at the same speed over a single pinion, the rotation of the latter is maintained at a speed dependent upon the length of working arc imparted to the gears by the connecting-rods through the rocking shafts. During the return movement of its connecting-rod each gear "free-wheels" on the pinion, and continues to do so until its working stroke again starts.



CRANK CONNECTING-RODS AND DRIVING ELEMENTS

By the use of four driving gear wheels in the variable speed gear, the pinion is maintained under constant driving load and at the slowest output shaft speeds, during the shortest working stroke of the connecting-rods, there is always an overlapping drive from two of the wheels to the pinion.



VARIABLE SPEED GEAR MECHANISM

The Development of Ultra High-Pressure Hydraulic Systems*

By S. M. PARKER, B.Sc.†

THE following definitions may be used with reasonable accuracy for equipment of this sort :—

Up to 500 lb per square inch	... =	Low pressure
500 lb to 1500 lb per square inch	=	Medium pressure
1500 lb to 3000 lb per square inch	=	High pressure
3000 lb to 5000 lb per square inch	=	Ultra high pressure

The first three ranges are in common use : the low pressure for a multitude of purposes, the medium pressure for many automobile and industrial applications, and the high pressure for most aircraft systems. In the lighter forms of engineering the ultra high-pressure range has hardly been used at all. The case for the use of ultra high pressure rests on the possibility of reducing weight and bulk without any departure from the necessary standards of reliability, ease of maintenance, and cost.

TRANSMISSION AND CONTROLS

The generation of hydraulic power and the use of it, and more particularly the equipment that is used for this purpose, has occupied far too large a place in some previous papers. In addition, so many of the fundamental problems of a hydraulic system are really transmission problems that no apology is needed for starting with that section of a hydraulic system which comprises the working fluid, the conduit and connections that enclose it, and the valves that direct it.

The first consideration must be the temperature range required and a figure of 120 deg. Cent. (248 deg. Fah.) is suggested, with suitable adjustment of the mean point to suit different applications. In aircraft systems normal operation must be achieved between 70 deg. and —50 deg. Cent. (158 deg. and —58 deg. Fah.); in industrial applications the maximum temperature may be 100 deg. Cent. (212 deg. Fah.) or more, with the lower temperatures correspondingly re-

* Institution of Mechanical Engineers. One of three papers read on January 3rd.

† Automotive Products Company, Ltd., Leamington Spa.

duced; and even for automobile work, assuming the same fluid for all climates, little reduction is possible. In addition, to meet these working temperatures it is most desirable that increase or decrease above or below them to the extent of about 20 deg. Cent. (36 deg. Fah.) should not cause complete stoppage of the system, although it may work less efficiently.

The fluid chosen must meet two conditions: at the highest temperature it must not vaporise appreciably, nor must its lubrication properties fall below the minimum necessary in a power pump; at the lowest temperature its viscosity must not rise to a point at which the transmission losses become unacceptably high—this latter point should not be confused with the solidification point, which is of academic interest only—and many fluids become too thick to be useful well above their solidification point. A definition of the maximum viscosity acceptable is therefore of considerable importance, and is easier to define from the aggregate of experience than from any purely theoretical considerations.

Hydraulic systems have a property—essentially different from electrical and mechanical systems—which has a most important effect on the above problem.

At the peak load, when the pressure from the power source is only just greater than the pressure required by the hydraulic motor unit, flow will be at a minimum, and transmission

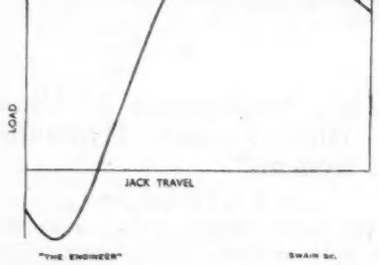


FIG. 1—*Typical Retraction Curve for Aircraft Undercarriage*

efficiency at a figure approaching 100 per cent. Therefore, high average losses in a hydraulic system are tolerable, and sometimes even desirable in order to achieve a simple form of speed regulation, because they disappear at peak loading. This feature undoubtedly provides the inherent flexibility and ability to withstand overload, which is the characteristic of a hydraulic system. For this reason hydraulics are widely used to deal with variable loads and under these conditions it is uncommon to achieve an average which is higher than 60 per cent of the maximum. This is no reflection on the hydraulic system itself, but is determined by external conditions, which Fig. 1, showing a retraction load curve for an aircraft undercarriage that is better than the average, will indicate.

If the system is supplied with a constant pressure at the power generation end, an average balance of 40 per cent will be available to overcome mechanical friction, to provide the necessary acceleration of masses, and to allow for line loss. Friction losses by careful design can be kept low—certainly less than 5 per cent and often as low as 1 per cent. The acceleration forces involved in moving masses of a few hundred pounds through only a few feet in several seconds are practically negligible, and therefore practically the whole of the 40 per cent is, in fact, expended in line loss.

In a high-pressure system it can be shown that losses, of the order of 1000 lb per square inch in pipe sizes of about 0·2in bore and in circuits 10–20ft long at speeds that are generally required, limit fluid viscosities to a maximum of between 500 and 1000 centistokes; this viscosity is approximately that of medicinal castor oil at room temperature.

In an ultra high-pressure system the percentage of line loss can remain the same, the lengths of piping remain the same, and the loss per foot run can be almost doubled, thus permitting smaller bore sizes but not affecting to any appreciable extent permissible viscosities.

Two basically different fluids are available to meet these conditions; one is a highly-specialised mineral oil of the type known by specification "D.T.D. 585," and the other is a combination of castor oil and a suitable solvent, known by specification "D.T.D. 641." The viscosity characteristics of these two oils are shown on Fig. 2, which also shows the maximum permissible operating viscosity. Viscosities are plotted on a logarithmic basis to make the characteristics approximately straight lines, and the convergence of the two fluids is apparent rather than real, since the viscosity of the mineral oil is always rather more than twice that of the castor base fluid.

It must, indeed, be obvious that the hydraulic engineer desires a fluid which changes its viscosity to the least possible extent over the working range of temperatures. As it is, a change of at least a hundredfold has to be accepted, so that included on the same scale is a dotted line representing the characteristics of one of the new silicone types of fluid now in the early stages of development. Over the same temperature range this fluid has a viscosity change that is only about tenfold, and if it became generally available at commercial prices its advantage to the hydraulic engineer would be very great.

At high temperatures hydraulic fluids are poor lubricants, but the best modern pumps are not sensitive to this. The upper limit of use is determined by the vaporising point of the most volatile constituent; in mineral oils this generally is a small percentage of the volume, and in castor base fluids it may be as high as 80 per cent. It is thus possible to operate mineral oil within 20 deg. Cent. (36 deg. Fah.) of its vaporising point, but with castor base fluids it is desirable to have a margin of about 40 deg. Cent. (72 deg. Fah.). By the use of suitable diluents, such as carbitol, the performance of both fluids is much the same at high temperatures, and both have a substantial margin in hand over the highest temperatures met with in aircraft systems.

It may be thought that the fluid having the lower viscosity is always to be preferred from a transmission efficiency viewpoint, but this is not so. In the high-pressure systems in use in aircraft, the losses with mineral oil at 20 centistokes are much the same as for castor base fluid at 10 centistokes, because the former is still laminar flow whilst the latter has become turbulent.

The use of ultra high pressure will not in itself greatly affect this, but the introduction of electrical control circuits to make the hydraulic system more compact (which is already accepted practice) will considerably reduce the length of piping in most installations—probably to less than half immediate past practice. Since, as previously shown, there is no purpose gained in reducing line losses below quite a substantial level, it is inevitable that large increases in linear rates of flow will take place. In that event both mineral oil and castor base fluid will give turbulent flow, and viscosity will be a matter of greater importance. At the lower temperatures in particular there will be a big advantage of the least viscous, and either a better mineral oil than D.T.D. 585 will be required or castor base oil will come back into more general use.

The pipe materials most commonly used are shown in the table below.

Pipe Materials Commonly Used

	Ultimate tensile strength.	Density.	Ratio.
Steel drawn tube or rolled strip...	25	7·8	3·2
Bronze drawn tube	25	8·85	2·92
Aluminium alloy drawn tube	9	2·70	3·33
Copper drawn tube	14	8·8	1·59

On a strength/weight basis, aluminium alloy is to be preferred, but it is not sufficiently ductile to permit the reliable use of flared fittings, and it is too soft to give good security with compression type fittings. Technical improvement in such alloys or the use of magnesium alloys may in time alter this position, but as far as can be seen steel pipe, though only slightly more unfavourable from the weight standpoint, is very satisfactory in other respects, and will continue to give good service in ultra high-pressure systems. Its ductility even in thicker gauges than commonly used will remain adequate, and the security it gives either with compression or flared joints is second to no other material.

The A.G.S. (Aircraft General Spares) flared joint, originally a low-pressure joint, will not in its present form provide adequate strength, and redesign of fittings will be necessary. There are, however, a number of designs capable of dealing with the higher pressures, and these can be used in their present form or as a basis for further development.

Control valves are at present mainly either of the poppet valve or of the slide-valve type. In the former the difficulty lies in balancing the hydraulic load sufficiently to make manual operation or remote operation reasonably light, and in the choosing of mating materials soft enough to provide a good seal at low pressure and of adequate strength at high pressures.

Static balance is easily achieved with slide valves of the piston type, but dynamic out-of-

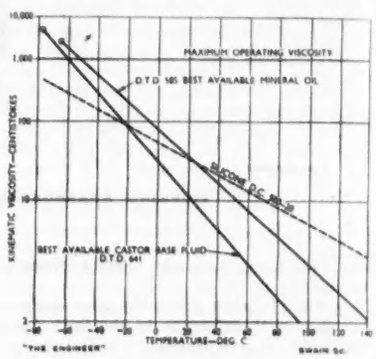


FIG. 2—*Viscosity Characteristics of Aircraft Hydraulic Fluids*

balance effects, and what may be termed power filtration (or the wedging of small impurities in the fluid into the working clearances), will be more noticeable. In neither case should the difficulties defy solution by careful detail design, and it should be possible to reduce the bulk of control valves somewhat; but section thicknesses will, as at present, continue to be determined by manufacturing considerations.

As has been mentioned, the replanning of the hydraulic system by use of electrical remote control will greatly reduce weight. This effect completely swamps the more modest gain that will result from the use of ultra high pressures. Even so, taking the present 2500 lb per square inch system as a yardstick, a saving of about 4 to 5 per cent of the total system weight should be achieved in transmission and controls, with other important gains in reduced bulk and easier installation.

Power Generation and Regulation

Hydraulic pumps delivering at 2500 lb per square inch give at present rather less than 1 h.p. output per pound of weight, with a minimum of about 5 lb. Development already indicates that a figure of nearly 2 h.p. per lb can be achieved at 5000 lb per square inch, with the same minimum of 5 lb. If greater power is required in the system of the future it will be available in an ultra high-pressure system with no increase in weight or bulk, but increase of pressure does not offer at present any reduction in weight for pumps of currently required capacity. As there is some indication of increased power being necessary, the use of higher pressures will be beneficial.

The best designs of hydraulic pump achieve

an overall mechanical to hydraulic conversion efficiency of over 90 per cent, and since this indicates low bearing and pumping losses no difficulty has been found in raising pressures by 70 to 100 per cent. This should apply equally to variable delivery pumps or fixed displacement pumps, with separate automatic pressure-regulating valves. In the latter case, increase in pressure has not involved fundamental alteration in the design of the regulator valve, but careful attention to high-pressure seal design is necessary.

Where stored energy is necessary, increase in pressure from the high to the ultra high range is not likely to affect hydraulic accumulator weights, although it will materially reduce size. If air continues to be used as the energy storing medium its retention at 5000 lb per square inch is not much harder to achieve than at 2500 lb per square inch. If cartridges are used for the supply of emergency power there is no difficulty in increasing the pressure required from them.

It would not be correct to leave this section of the system without referring to that simple but bulky part—the supply tank. Whilst an appreciable volume of fluid is always required as a circulating medium to avoid overheating, it should be possible to reduce considerably the volume of fluid carried. Indeed, this will be the greatest contribution towards decreased weight and bulk that can be derived from increased pressure.

Again, taking the 2500 lb per square inch system as a yardstick, this factor, together

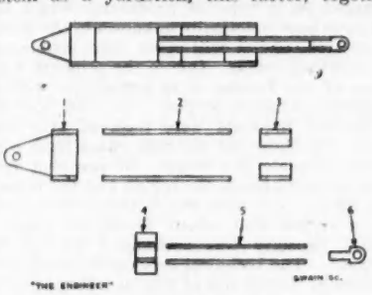


FIG. 3—*Diagram of Principal Component Parts of Hydraulic Jacks*

with some advantages from increased power to weight ratio in hydraulic pumps, should provide a saving of about 3 per cent of system weight and less demand on installation space.

Conversion to Mechanical Work

Without question, the use of 5000 lb per square inch in hydraulic jacks is something that needs the most careful assessment. Rotary motors are used in some forms of hydraulic mechanism, but they are the exception rather than the rule, and the use of means of providing linear motion—the primary function of hydraulic mechanisms—is the only one that can be considered in a paper of modest length.

No one, least of all a hydraulic engineer, would suggest that the present high-pressure equipment at 2500 lb per square inch has anything to spare in the way of reliability, if it is coupled with high efficiency. Indeed, the author would go further and put forward the view that such equipment is adequate by such a small margin that it is, to a first approximation, unsatisfactory. Certainly no higher assessment can be used as the jumping-off place for further development to higher pressures. Without question this state of affairs demands realisation of the limitation of present methods and an entirely new approach to the problem.

In addition there is an obvious structural limitation which must be stated. As pressures increase, jack diameters decrease in proportion, and piston rods, which must be considerably smaller than jack diameters, decrease also; a point is reached where even if they are solid they fail to provide adequate strut crippling strength. Where this point is necessarily depends on the length of the piston rods, for whilst it is not impossible that users of hydraulic equipment may be prepared to accept slightly reduced jack travels for a given load, it would be unwise in the extreme to assume that any large change would be generally acceptable. Furthermore, it is clear already that at 2500 lb per square inch the piston rod section thicknesses at present being used are as great as is consistent with weight economy, and it is not surprising that there are those who think that present pressures are as high or higher than is desirable.

As a first step it is necessary to assess these difficulties with the greatest accuracy possible. From the functional standpoint the only major problem is that of suitable sealing means, and here the difficulty lies chiefly in the moving seals; any near solution of this problem will without question supply a satisfactory answer for stationary seals.

There are many who assume that the function of a seal is to prevent any passage of fluid past it, but this is incorrect. No relatively moving parts under heavy loads can work continuously without lubrication, and this is as true of moving seals as of any other mechanism. It is in the author's view imperative to recognise that a seal must permit the passage of a minute but finite film of lubricant, but must so control this that it cannot be termed a leak. Any attempts to ignore this fact will lead to a low standard of reliability and life, which is the exact opposite of the principal attributes of a well-designed hydraulic system.

The commonest form of seal material is natural or synthetic rubber, compounded in many different ways, but with the main objective of providing stability of physical properties when in contact with the working fluid over a long period. In shape there are almost countless varieties, from rectangular section rings to cups with complex lip and heel shapes. The purpose of the latter is to avoid direct rubber compression as far as possible, and thus reduce friction particularly when not under pressure. This feature is of decreasing value as working pressures increase.

Nor should it be overlooked that, at 2500 lb per square inch and over, the working pressures are becoming of the same order as the rupturing strength of the material being used, so that a seal that is good enough to prevent lubrication will suffer additional friction effects that are additive to its direct loading, and which will therefore lead to disintegration as a corollary of its own design perfection.

Extrusion effects, which are not unknown with stationary seals at high pressure, are a direct indication of the small margin of strength possessed by many rubber compoundings. It is possible to obtain some relief from these conditions by the use of fabric reinforcement, but this necessarily reduces the compressibility of the material and makes it difficult to obtain a good seal without the use of some additional mating force that increases friction. This tends to repeat the vicious circle, but it is often inacceptable in sensitive mechanisms on other grounds.

What then is the solution of the problem? Surely it is fundamentally that of accepting a small but finite leak to achieve lubrication, and adding a low-pressure seal between the leak and atmosphere. It may be thought that this solution involves too much complication; and so, before describing means of achieving it, it will be necessary to revert to the problem of structural strength of a jack—which seemed an even worse limitation.

Fig. 3 diagrammatically shows a typical hydraulic jack, and separately its principal component parts; it should be considered as being required to provide a given thrust, irrespective of the pressure chosen. The part numbered (1) is mainly controlled by jack thrust and will remain constant with varying pressure, although for manufacturing reasons it is usually possible to save weight if the pressure is increased and the bulk decreased. In the most economical form it may be integral with (2), which is controlled by bursting stresses. The wall thickness will increase directly as the square root of the pressure, but the circumference will decrease in the same way, thus leaving the weight independent of pressure for a given thrust. Parts (3) and (4) must, together, be long enough to give adequate sideways support for the telescoping members when fully extended, and thus reduce in weight as the pressure increases. Part (6) is constant and (5) is the critical component.

The majority of applications require that the tensile effort of the jack should not be less than about 75 per cent of its extending thrust. This limits the diameter of the piston rod to a maximum of half the diameter of the jack. The stroke/bore ratio required at 2500 lb per square inch varies between 4/1 and 6/1 for small jacks, up to 8/1, and very occasionally 10/1, for large jacks. Even if the user would accept some reduction in these figures, it is necessary to be able to offer 6/1 without appreciable weight penalty, and 8/1 if a penalty is accepted. The piston rod will therefore have a ratio that is twice this figure, namely, 12/1 and 16/1. To utilise material efficiently, the section thickness should not normally exceed 10 per cent of the diameter and 15 per cent should be the maximum in any circumstances.

With these limitations and allowing a working factor of 2, the crippling loads correspond to a working pressure of 2600 lb per square inch for a 6/1 stroke bore ratio jack, and 2300 lb per square inch for an 8/1 jack. It is thus clear that a working pressure in the region of 5000 lb per square inch is not possible; and even if piston rods were solid, the figures would only be of the order of 5000–6000 lb

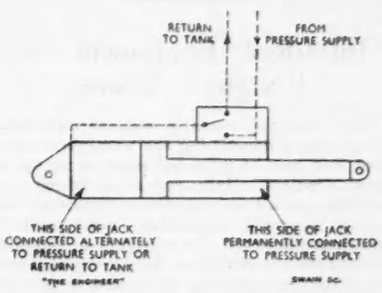

RETURN TO TANK
FROM PRESSURE SUPPLY
THIS SIDE OF JACK CONNECTED ALTERNATELY TO PRESSURE SUPPLY OR RETURN TO TANK
THIS SIDE OF JACK PERMANENTLY CONNECTED TO PRESSURE SUPPLY
"THE ENGINEER"
SWAIN SC.

FIG. 4—*Diagram of Suggested Hydraulic Jack of Improved Design*

per square inch. There is, however, a solution to this problem if the size of a jack for a 2500 lb per square inch system is retained for a 5000 lb per square inch system.

If *both* sides of the jack are together connected to the pressure source, it will extend against a force equivalent to the difference of areas of the two sides; that is to say, the area of the piston rod. To contract the jack, pressure is applied to one side only, and for similar thrust capacities this arrangement permits the piston rod diameter to be increased by 50 per cent—thereby allowing more efficient use of material. Thus, at 5000 lb per square inch, the piston rod will be lighter than at 2500 lb per square inch. On the other hand, the cylinder tube will be somewhat heavier, but other parts will not be affected to any great extent.

This arrangement allows the mounting of a control valve on the jack itself, and this valve only controls flow to or from *one* side of the jack, since the other side is constantly connected to pressure. Fig. 4 shows this arrangement. It will be apparent that the flow in each line is unidirectional only, and one line only is subject to full pressure. The return line can be of reduced thickness as it deals with low pressures only, and any duplication of supply that may be necessary can be provided automatically by simple non-return valves.

Whilst it is doubtful in the extreme whether any weight saving could be expected in the jack itself if pressure were raised to 5000 lb per square inch, there would be savings in other parts of the system that are the direct result of this form of jack design. Whilst it is very difficult to assess accurately, a saving up to 5 per cent of the 2500 lb per square inch system weight should be possible.

It will also be seen that this design of jack,

having a permanent low-pressure line attached, lends itself particularly to the gland arrangement mentioned previously. Leakage from high-pressure seals can easily be taken away without extra pipes.

Conclusions

None of the savings mentioned in the three sections is of spectacular size, but it is the author's considered opinion that, in the aggregate, the raising of pressure from 2500 to 5000 lb per square inch in light hydraulic systems would reduce weight of aircraft equipment by about 10 per cent. This should not be confused with a further saving of the same order that should arise from more intelligent replanning of the system as a whole, irrespective of the pressure at which it works. The size of components and pipes would be appreciably reduced, and there is no reason why the use of ultra high pressure should prevent necessary improvements in standards of reliability and maintenance.

Finally, the author would mention that he is only too well aware of the dangers of prophecy but that in his opinion light hydraulic engineering has reached the cross-roads where indecision is the only indefensible attitude. Time may well prove some of the above conclusions ill-founded, but it is hoped that they will serve to promote the thought and discussion that is essential to the future of the industry.

Infra-Red Equipment for "Night" Vision

The Admiralty recently released some interesting details concerning the wartime development and use of infra-red equipment by the three Services. Infra-red rays, which were invisible to all except those provided with special receiving apparatus, were used for signalling purposes. This system of signalling contributed materially to the success of numerous operations on sea, land and in the air: the midget submarine attacks on the "Tirpitz" and on Japanese warships, the sinking of the large floating dock at Bergen in September, 1944, and more than 100 combined operations, ranging from the North African landings to the assault on the Arakan coast of Burma. In the air R.A.F. night fighters were fitted with infra-red receivers, while the tails of friendly fighters carried infra-red identity lights. As the radar-guided fighters closed to attack, an infra-red sight aligned alongside the gun sights allowed friend to be distinguished from foe. The application of infra-red rays to Britain's military use was developed by the Admiralty with the help of a number of British manufacturers. One of the first steps was the production at the E.M.I. research laboratories of a cell sensitive to infra-red radiation and suitable for military use. This detecting element was used in receiving instruments for many different applications. The complete receiving instrument resembles an ordinary telescope, except that between the lenses is a special device which converts invisible infra-red rays into green light. The signalling equipment which produces the necessary infra-red radiation consists of a small instrument weighing 1¼ lb with its self-contained power supply, which can be operated single handed. By way of comparison, the equivalent German signalling equipment—"Seehund"—weighed 16 lb without its power unit, and offered no gain in sensitivity. One of the interesting technical problems that had to be solved in the development of the British apparatus was that of obtaining a light and compact 3000-volt supply. The problem was solved in 1941 by constructing a dry pile battery which was the first practical application of the work of a Swiss priest, Abbé Zamboni, more than a century ago! The modern Zamboni pile is made from small discs of paper coated with manganese dioxide on one side and with tin foil on the other, an arrangement well adapted to the immediate purpose, which requires a high voltage and a very small current of less than one thousandth of a microampere.

Leaded Alloy Steels

Apart from that class of steel falling within the narrow field of "free cutting" steels, little progress was made towards improving the machining properties of ferrous materials until the years immediately preceding the second World War. Then the knowledge that a small lead content in certain non-ferrous materials resulted in a marked improvement in their machining properties was applied to steel and beneficial results were obtained. The original experiments which culminated in the successful development of lead-bearing steels were carried out by the Inland Steel Company of America, who hold patents covering the methods employed. By agreement, Messrs. Ledloy control these patents in this country and a licence to manufacture by such means all qualities of steels was granted to the United Steel Companies, Ltd., in 1940.

Investigations were immediately begun at the works of Samuel Fox and Co., Ltd., into the application of the process to alloy steels and the first leaded ingot was made in March, 1941. Apart from the efforts to perfect the production technique, particularly to ensure even distribution of the lead throughout the material, considerable work was done to ascertain what effect the lead addition would have on the other properties of the steel. For this, advantage was taken of the fact that the lead is added to the stream of steel issuing from the nozzle of the ladle during the teaming of the ingots. Thus it was possible to produce two ingots from the same cast, the only difference being that one contained lead and one was lead free. By checking the various properties of the products of these two ingots against one another, the effect of the lead was evident. The late Dr. T. Swinden published in the *Journal* of the Iron and Steel Institute No. II for 1943, a paper entitled "Leaded Manganese Molybdenum Steel," which gives details of the results of such an investigation. Work on similar lines has been carried out on the majority of the more popular alloy steels. Speaking generally, the leaded steel meets, in all respects, the requirements of the specification drawn up to cover steel of the same analysis but without lead.

A perusal of the papers and discussion which took place at the recent Conference on Machinability organised by the Institution of Mechanical Engineers convinces one of the difficulty of assessing the property of machinability. There are so many different types of machining operations and the variables in each are so numerous that it would be unwise to make any dogmatic statement as to the degree of improvement likely to be brought about by the addition of lead to a particular alloy steel. In the development work turning tests of the "Losenhausen" and "tool breakdown" types were employed for testing purposes and are still used as a standard method of checking this property. Now that leaded alloy steels have progressed beyond the development stage and large-scale trials are in progress with many of the motor manufacturers, production experience is rapidly becoming available. Varying results have been obtained, but the variation has been confined to one of degree. Practically without exception, users report not only a reduction in the time necessary to accomplish one operation as compared with straight alloy steels, but also a considerable improvement in the life of the cutting tool and a superior finish obtained on the completed part, in spite of the higher cutting speed.

It is probable that these practical advantages will lead to a still wider adoption of this class of steel. The rate of development already achieved is illustrated by the fact that compared with the orders placed during the year July, 1944, to June, 1945, the volume of orders for the following year was six times as great. Judging by the first six months this year, it appears that the volume will be stepped up by as much as twenty times the original figure.

The North-East Engineering Bureau

At the recent annual meeting of the North-East Engineering Bureau held at the Guildhall, Newcastle upon Tyne, the annual report for the year ended December, 1946, was presented. It is interesting to record that the membership of the Bureau rose from 94 at the beginning of January, 1946, to 119 by the end of the year. These firms represent approximately 49,000 of the employed engineering labour coming within the scope of the Bureau's activities. During the year some 4500 copies of the brochure entitled "The North-East: The Home of Engineering," have been distributed throughout this country and abroad, and requests for it continue to be received. In facing the employment problem on the North-East Coast after the war, it was early recognised that it would be essential to provide employment for over 100,000 persons within seven to ten years after the cessation of hostilities. Recent Board of Trade figures show that since the Distribution of Industries Act came into force, fifty-six new engineering factories have been approved for the area, involving a total floor space of about 3,500,000 square feet. In addition, no fewer than ninety-two extensions to existing factories have been approved, with a floor space totalling approximately 3,000,000 square feet. This total of 6,500,000 square feet should provide employment for over 30,000 persons. Many of these new firms will be engaged on a type of production which has hitherto been practically unknown in the North-East area, and it will cover light engineering in its widest terms. One of the principal functions of the Bureau is in connection with its capacity exchange service. In 1946 over 500 individual inquiries were received and dealt with. Of these, 45 per cent came from companies outside the region, 20 per cent from non-members inside the region and the remaining 35 per cent from the members themselves. It is known that about £4,500,000 value of direct capacity was exchanged through the Bureau. The technical services of the Bureau embraced the lay-out of two new foundries, the reorganisation of a medium-sized foundry and the preparation of five costing systems and three store-keeping systems. The Bureau is forming a provisional committee on research and an apprenticeship scheme. It is co-operating closely with the Northern Branch of the Engineering Industries Association. To fill the vacancy on the board of management caused by the appointment of Colonel B. H. Leeson as Director of the British Electrical and Allied Manufacturers' Association, London, Mr. H. Noble, of Noble and Lund, Ltd., has been elected to the board, while the services of Mr. N. Parry, general manager of Aveling-Barford, Ltd., of Scotswood, Newcastle upon Tyne, have been co-opted.

Technical Reports

Bituminous Coatings for the Protection of Iron and Steel Against Corrosion. D.S.I.R. Chemistry Research Special Report No. 5. H.M. Stationery Office. Price 1s. —More than £40,000,000 is spent every year in Britain to protect iron and steel from rust, and the world's losses due to rust are estimated at £500,000,000 a year. Coal tar not only forms a fruitful source of many intermediate compounds but is also used directly, after simple processing, for many industrial processes. The protection of iron and steel surfaces against corrosion is an outstanding application. During the war, tar had to be used as a replacement or substitute for many imported materials. The necessity for their use remains in peacetime, so it has been considered opportune to collect and review existing information on bituminous materials generally. The purpose of the report is to stimulate interest and experiment in the use of coal tar and bitumen for the protection of iron and steel against corrosion. Whilst coal tars have been kept in mind, information has been sought on the properties of allied materials which might prove useful in corrosion prevention. Special mention of immersed conditions and anti-fouling compositions for use on ships' hulls is included.

Conversion of French Locomotives to Oil-Burning

(By our French Correspondent)

As part of the national campaign to save coal, the S.N.C.F. has decided to equip 620 steam locomotives to burn oil instead of coal; 300 class "141-R" locomotives will arrive fully equipped from America and 320 will be equipped in France.

Work involved in the conversion will include the removal of the mechanical stoker and the installation of oil heating apparatus on the tender. The S.N.C.F. also has to provide equipment in the sheds in which oil can be stocked and distributed, and to construct about 100 storage tanks, each with a capacity of about 1000 cubic metres, and pumping installations, &c., at a cost of over half a milliard francs.

French steam locomotives are in general designed for coal combustion, and with coal firing the size of the grate is a critical factor. With oil firing the critical factor is the volume of the firebox. The "141-R" class was chosen for conversion because of its relatively large firebox (7·8 cubic metres), and was considered to have suitable dimensions for oil firing.

The first "141-R" locomotives equipped to burn oil have already arrived, and about fifty will be used on lines in the Marseilles region. By the end of 1947 the 620 locomotives will be distributed, giving 90 on lines in the east, 180 in the west and 350 in the south-west.

A converted "141-R" locomotive has been tested in the test house at Vitry, and results already obtained show that an output of 2000 h.p. may be reached on the bench, with the possibility of increasing the output to 2500 h.p. An accompanying engraving illustrates one of these locomotives on test. While it is still too early to give consumption figures likely to be obtained when locomotives are in service, it is expected that the S.N.C.F. total oil fuel consumption for 1947 will be 600,000 tons, increasing to 1,000,000 tons in future years.

FRENCH OIL-FIRED LOCOMOTIVE ON TEST AT VITRY

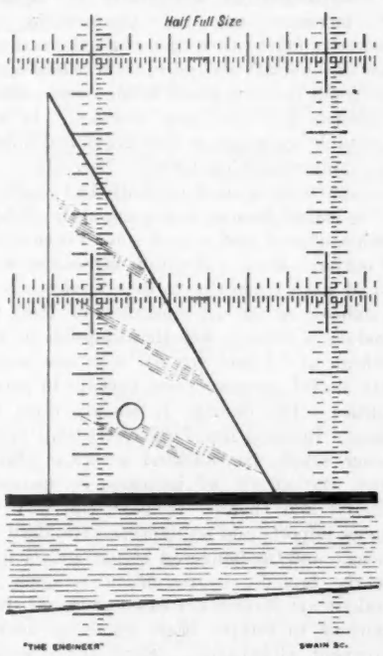
CAR FITTED WITH SPECIAL CONTROLS

Squared Drawing Paper

We have received from Hall, Harding, Ltd., of Dacre Street, Westminster, samples of "Celemeter material" As will be seen from our half full-size illustration, this material has 3in squares with the vertical and horizontal lines subdivided in eighths of an inch printed on the paper. The colour of the printing is light. The makers inform us that at present they are only producing this material in one-eighth scale, but propose in the near future to print "Celemeter material" in ¼in, ½in and 1in scale, and also further subdivisions of one-tenth and one-twelfth, and eventually in metric scale.

The material consists of a paper or cloth base and is also printed on transparency, the ruling on the latter being of such a colour that it will not reproduce on a photographic print. By the use of "Celemeter material" the difficulty experienced by the change in atmospheric conditions and the consequent stretching and shrinking of the paper is to a large extent overcome, since the scales will, of course, move with the material, thus enabling the draughtsman to complete his drawing without the objection of one portion being of a slightly different scale from another.

The use of backing paper with this type of ruling facilitates considerably the speed with which rough lay-outs can be made, and the open grid tends to prevent to a large degree the eye strain that usually accompanies working on a closely ruled squared paper.



SQUARED DRAWING PAPER

Equipment for Limbless Motorists

Equipment to aid limbless drivers of motor-cars has been under development for some time by the Rootes Group of vehicle manufacturers, in conjunction with Thomson and Taylor (Brooklands), Ltd., of Weybridge. This equipment, we learn, has now been put into production and will soon be available. The equipment, of which a typical example is illustrated, can be fitted to any Hillman "Minx" or Sunbeam-Talbot 10 car, and supplements the normal driving controls, so that the car can still be driven in the normal way. The design of the controls is such that they can be readily transferred from one car to another. To reduce physical exertion to the minimum, the controls are power-assisted by Clayton Dewandre vacuum-servo motors.

There are five components in the complete range of controls, and, in addition, the accelerator pedal and gear lever can be placed to the right or left of the driver, as required, and the hand brake lever can be moved to the right-hand side. By means of selecting from the range the appropriate controls and fitting them to the car, it is possible for any of nine classes of limbless persons, ranging from loss of both legs to loss of one leg and one arm to drive.

The five main components are:—(i) Combined hand throttle and clutch, shaped to take two fingers of the right hand. This control is vacuum-assisted; lifting the lever operates the clutch, rotating it opens the throttle. (ii) Brake control, vacuum-assisted, which moves approximately 20 deg. in rotation with the steering wheel; lifting it towards the wheel operates the brakes. (iii) Combined foot brake and clutch, obtained by modifying the standard brake pedal and fitting it with an extension hinged in the centre. The lower portion of the pedal is connected to the vaccum servo-motor and the clutch, and is operated by the driver's right heel. The upper portion is operated by the toe to apply the brakes. (iv) Combined clutch and brake for the left foot. This control is similar to (iii), but in this case the lower portion operates the brakes and the upper portion the clutch. (v) A gauge on the dashboard indicating the vacuum in the reserve vacuum tank, with a luminous dial.

Tests are said to have shown that an experienced motorist can get used to these special controls in half an hour, and that a new driver can learn as quickly as with normal controls.

The illustration herewith shows controls which are suitable for a legless driver; a driver with left leg amputated; a driver with right arm amputated; or a driver with left leg and right arm amputated.

Electricity Generation.—A written Parliamentary reply by the Minister of Fuel and Power states that it is estimated that the additional generating capacity which will be available for the public supply of electricity will be 2,600,000 kW by the end of 1949, 4,460,000 kW by the end of 1950, and 5,660,000 kW by the end of 1951. These increases will not be sufficient to meet the increased demand until the winter of 1950–51, but should then be sufficient, the Minister says, provided certain obsolete plant is still kept in commission.

THE ENGINEER

FEBRUARY 14, 1947

VOL. CLXXXIII No. 4753

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

For Subscription Rates, see page 2 of Advertisements.

SUSPENSION OF PUBLICATION

ONLY once in over ninety years of existence has THE ENGINEER temporarily ceased publication. Two issues for May, 1926, are missing from the first volume of that year of the General Strike. Nor, short of invasion or the dropping of atom bombs could Hitler's Germany have prevailed to cause even a single interruption of our continuity. For from the days of Dunkirk onwards we held ready for immediate printing outside London a small "emergency" issue for use should bombs or rockets disable our printers or temporarily disorganise the editorial machine. But now, in a time of international and industrial peace, we are forced temporarily to cease publication. At the behest of the Ministry of Fuel and Power, and in company with all other weekly periodicals and trade and technical papers throughout the country, publication of THE ENGINEER will be suspended for "at least two consecutive issues." The issues of February 21st and 28th will not therefore appear. We dislike this interruption. We dislike still further the note of doubt regarding further issues. But we can do no more than promise an immediate resumption as soon as some relief of the present state of emergency permits. The pen, it is said, is mightier than the sword. Coal, it seems, is mightier than either.

COAL

THE sudden revelation, last Friday, of the critical condition of our coal supplies gave a shock to the whole country. But that a state of emergency should have arisen occasioned far less surprise in industry than it did amongst the general public. For it had become unpleasantly clear to many industrial firms two months ago that the supply of coal was already reaching a "hand-to-mouth" basis at the very time when stocks in hand should have been relatively high to meet the winter demand and to cushion interruptions of distribution imposed by inclement weather. In fact, those stocks were lower than they had been at that time of the year in any year of the war and far lower than was normal in peacetime.

As long ago as last July, when the coal supply situation was debated at length in Parliament, the possibility—even perhaps the probability—of a coal supply crisis during this winter could be foreseen. Nor in writing these words are we in any sense being wise after the event. For in commenting upon the debate we wrote: "Should the winter prove unusually hard, should demands for gas and electricity be under-estimated even by a trifling amount, should the output of the mines fail even by as little as 1 per cent to reach the expected quantity, then the productivity of the engineering and other works of this country must inevitably be seriously interrupted as a consequence of shortage of fuel." In fact, of course, despite a fall in the numbers of those employed in the production of coal, the output of the miners has tended to show in recent months a welcome, even if not a very considerable, rise. But the demands of industry upon light, heat and power have risen during the same period very markedly. That rise, no doubt, is to be attributed to the effort to attain an increased rate of productivity in answer to urgent Governmental exhortations that the quantity of exports must be increased and goods made available in more reasonable quantities for the home market. As an inevitable consequence coal stocks had fallen to a dangerously low level by December. A mere fortnight or so of unusually bad weather at the end of January disorganised the distribution of coal and caused some diminution of output. Such a situation before the war would have given rise to little anxiety. But it sufficed, in the circumstances of 1947, to produce a crisis. Yet the adoption of an attitude of "I told you so" can now serve little useful purpose except perhaps in party politics. The damage is already done or doing. Bringing into force restrictions upon power supply has inflicted a serious check upon the efforts of industry to increase exports and thereby to pave the way to higher imports and an improved standard of living; and the danger of serious inflation is clearly brought nearer when millions of workers are thrown out of employment, but continue to receive basic wages or unemployment allowances. Even those works which are situated in districts unaffected by power cuts and which are thus able at present to remain in operation must sooner or later experience a check owing to non-delivery of raw materials, parts or assemblies from works that have been closed down even if emergency measures are not extended to those areas. Nor will damage be confined only to the actual period of shut-down. Production programmes have been disorganised. Delivery dates will not be held. The after-effects must necessarily persist far into the remaining months of the year.

Politicians may safely be left to criticise the actions of the Government and its failure to inform the country of the situation or to take action by some form of rationing early enough to avert so widespread a stoppage. But industrialists and engineers will hope that the events of the last few days will have impressed upon the Government how paradoxical it is to urge industry to ever higher production when coal supplies are limited. For, in fact, it is idle to suppose that the industrial output of this country can be raised to higher and higher levels unless the output of coal from the pits shows a steady and rapid corresponding improvement. The productivity of industry depends, not only upon the hard work of its employees, but also upon mechanisation; and of what use is it to mechanise if the extra power to supply the new machinery is not forthcoming? Nor can it be forthcoming in a country dependent predominantly on steam power if coal is lacking to burn beneath the boilers. Moreover, it may further be added that not a few of those raw materials which are in such short supply as to hamper industrial production would become immediately available in less restricted quantities had we coal available for export from this country in exchange. Indeed, it may well be suspected that the failure of industry in the last months of 1946 to regain or to improve upon the level of exports attained in July can be traced more to a shortage of coal acting directly or indirectly upon output than to any other single factor. It is unquestionably of great importance to the economy of this country and for the standard of living of its people that exports should reach as soon as possible a level at least 75 per cent above that ruling pre-war and that sufficient consumer goods should reach the home market from our factories. But it is abundantly clear to engineers that further progress towards those much-desired targets cannot be expected until the output of coal from the mines shows a substantial improvement. The prosperity of Britain at the end of the nineteenth century was founded upon the existence of cheap and abundant supplies of coal. The present crisis demonstrates that recovery of our prosperity must be based upon the same factor.

THE ATOMIC ROCKET

MUCH of the sense of urgency which attends the discussions of the United Nations Atomic Energy Commission may safely be attributed to a fear of atomic warfare in general and of the long-range atomic rocket in particular. Dangerous as is the aircraft so armed, the rocket is much the greater threat, for in its case no means of defence is yet in sight. Although no official details have been authorised for issue which give the size and weight of the Hiroshima and Nagasaki bombs, we have been told at least something about them both, and a good deal more as to their amazingly destructive power. Some months ago we drew as good a composite picture of the Hiroshima bomb as was possible on the information available. On the basis of an estimate of its weight, about 4 tons, we pointed out the difficulty of designing any long-range rocket to take so massive a war head. The German V2 carried but 1 ton, and that for very short ranges. It is a

fairly simple deduction that for any ocean crossing a top speed of at least 2 miles a second would be necessary; whilst at that speed the sheathing of air in contact with the rocket casing, on ascent and descent, must reach a temperature in the neighbourhood of 5000 deg. Cent., a factor gravely hindering design and operation. The likelihood of any such rocket appearing in the near future seemed remote. Now, however, there is published by a member of the British Interplanetary Society—which, no doubt, is as keen on developing ultra high-speed rockets as the rest of the world is keen on never seeing them—a much more rude account of our prospects. It is claimed that an exhaust jet velocity up to 2 miles a second, with a ratio of laden weight to empty weight as high as 7, "should soon be realised," causing the rocket speed to rise to as much as 3 miles a second. This conclusion, of which most people will learn with little trace of enthusiasm, would enable Atlantic crossings easily to be made. Nature, however, fortunately provides that the temperature of the air sheath around the rocket would then rise to some 10,000 deg. Cent., and this temperature, though short lived, no doubt, may well present such an obstacle to the designer as to render the prospect of travelling at 3 miles a second whether for interplanetary trips or for anything else, as remote as many will no doubt hope it may long remain. Nor, as it happens, does there seem to be any great chance that the youthfully adventurous will be able to travel, even at quite modest speeds, in any of the regions much beyond the stratosphere, with either comfort or safety. We are told that in those brilliant sunlit realms of almost complete vacuum the steady temperature due to solar radiation may bring the whole rocket up to the boiling point of water, and that the intense showers of cosmic rays, from which the earth's atmosphere is our normal shield, may well bring death to all exposed to that ferocious bombardment.

Nevertheless, there will be some who are hard to reassure by any sedative conclusions based on mere calculation, and who simply trust that any forecast the interplanetary folk may make will in the end turn out to be wrong. After all, that prophetic writer, H. G. Wells, was rash enough once to descend to calculation, for in his "The Man Who Could Work Miracles" the miracle worker brings the story to its close by causing the earth, though not its surface fitments, suddenly to stop its diurnal rotation, whereby all the inhabitants of the village find themselves suddenly flying over the now stationary earth at the peripheral speed of 500 to 600 m.p.h., which, Mr. Wells assures his readers, is "about nine miles per second—that is to say, much more violently than if they had been fired out of a cannon." This little calculation, based apparently on there being but sixty seconds to the hour, has survived from the first day it was written—in 1895—to an edition issued as lately as last year! And were readers in these later days not so "rocket conscious" as they have to be when velocities in miles a second are part of their normal mental food, it might have gone unchallenged through even further editions. We have all heard, no doubt, of still greater mistakes being made in really difficult calculations: astronomers and meteorologists—but not engineers—have, we believe, on certain occasions omitted multipliers, or divisors, as large as a million and have had their little slips uncorrected for years. And if such a simple calculation as that made by Wells can go wrong in the hands of so earnest a prophet, may there not after all be a valid hope that the long-range atomic rocket is a good deal further off materialisation than the interplanetary enthusiasts expect?

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

INCREASE PRODUCTION?

SIR,—After reading all of the articles which have been written in the daily Press and engineering periodicals concerning increased production, &c., the layman would be under the impression that "engineers" are in great demand, but I am wondering from my own experience whether this is so, or whether the "boards" are finding it necessary to select men "capable" of doing the job and paying them on the "lower salary scale."

After serving sixteen months overseas with the Control Commission for Germany, I have been back in England four months and all of that time I have been endeavouring to find a suitable position. My qualifications are not exceptional, but include membership of two engineering institutions and executive experience extending over a period of ten years in positions of works engineer, factory superintendent and production manager, and yet it would seem that my abilities are not required.

So far, I have applied for thirty positions and have only received three replies, and all of these require someone in the "lower salary scale," but still they must have the "correct amount of experience."

I wonder whether other engineers are finding conditions the same or whether there are still vacancies where managements are willing to pay a salary commensurate with the job.

Ex-C.C.G.

February 11th.

Literature

SHORT NOTICES

A Plan for Kingston-upon-Hull. By Edwin Lutyens and Patrick Abercrombie. London and Hull: A. Brown and Sons, Ltd. 15s. net.—The report prepared by Sir Patrick Abercrombie and the late Sir Edwin Lutyens on the reconstruction of the city and county of Kingston-upon-Hull has now been published in the form of a handsome volume, with reproductions of the original maps and diagrams.

By its geographical position Hull is the port of Yorkshire and of the Midlands, but it also was the natural target of enemy assault during the war and suffered much. In fact, it is one of the three most bomb-damaged areas in the country. Like Plymouth and other ancient and important centres of our land, Hull deserves careful and far-sighted planning for its reconstruction if its citizens are to turn to advantage the destruction wrought by the enemy. Turning over the leaves of this plan, and unfolding the numerous plates, maps and diagrams, we are at once impressed with the artistry and meticulous care exercised by its authors and publishers.

Sections of the report deal with possible improvements in communications. Particularly interesting are the discussions and plans for eliminating railway level crossings and faulty road lay-outs. No less interesting are the proposals for industrial development and zoning, to bring together the scattered factories and workshops into three main areas, and the plans for improvement of the River Hull, by barraging, widening and dredging, to give sheltered water communication between the River Hull industries and the deep Humberside docks. Wherever the volume is opened it is apparent that all aspects of the life of the city have been considered and integrated. Finally, the manner of the presentation of the plan could hardly be bettered.

London Building Law. By H. R. Chanter, F.R.I.B.A., F.S.I. London: B. T. Batsford, Ltd., 15, North Audley Street, W.1. Price 21s. net.—This is an introduction and guide to the requirements of the London Building Acts, 1930 to 1939, and the by-laws made thereunder. It is not claimed to mention in detail every section and every clause of the numerous Acts, by-laws and regulations, but to provide a comprehensive digest which, by the use of simple language, gives a clear understanding of the law as it relates to normal practice. Not only will it prove of use to architects, surveyors and students, but also to builders, contractors, property owners, &c., concerned with the design, construction or alteration of buildings in the Metropolis.

The Institute of Petroleum Electrical Code. London: The Institute of Petroleum, 26, Portland Place. 1946. Price 5s. post free.—This book has been published to meet the need for a document presenting the considered views of the oil industry on the selection and methods of installation of suitable electrical equipment for the various operations encountered. Its publication should assist those British manufacturers who are interested in supplying the oil industry's needs, for the Code should eliminate the great diversity of practice prevailing hitherto on oilfields and to a lesser extent in refineries and installations overseas. In preparing the Code account has been taken of the practice adopted by the major British oil companies and of the recommendations and specifications produced by such bodies as the Institution of Electrical Engineers, the British Standards Institution and the appropriate Ministries. Although the rules and recommendations contained in the suggested code of practice are comparatively brief, the arguments upon which they are based are detailed in a number of schedules. One of these schedules reviews the incidence of fire risk from electrical causes, classifies the conditions giving rise to such a risk and discusses preventative measures. Other schedules deal at some length with the problems raised by static electricity and lightning. In a foreword the Council of the Institute point out that the Code represents their present views and is issued at this stage with the object of gaining experience in its application, after which it will be reviewed and either confirmed or amended in the light of such experience.

BOOKS RECEIVED

The Book of Road Signs. By Dudley Noble. London: The British Road Federation, 4A, Bloomsbury Square, W.C.2. Price 2s. 6d.

Inventions, Patents and Monopoly. By Peter Meinhardt. London: Stevens and Sons, Ltd., 119, Chancery Lane, W.C.2. Price 25s.

The Story of Water Supply. By F. W. Robins. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 18s.

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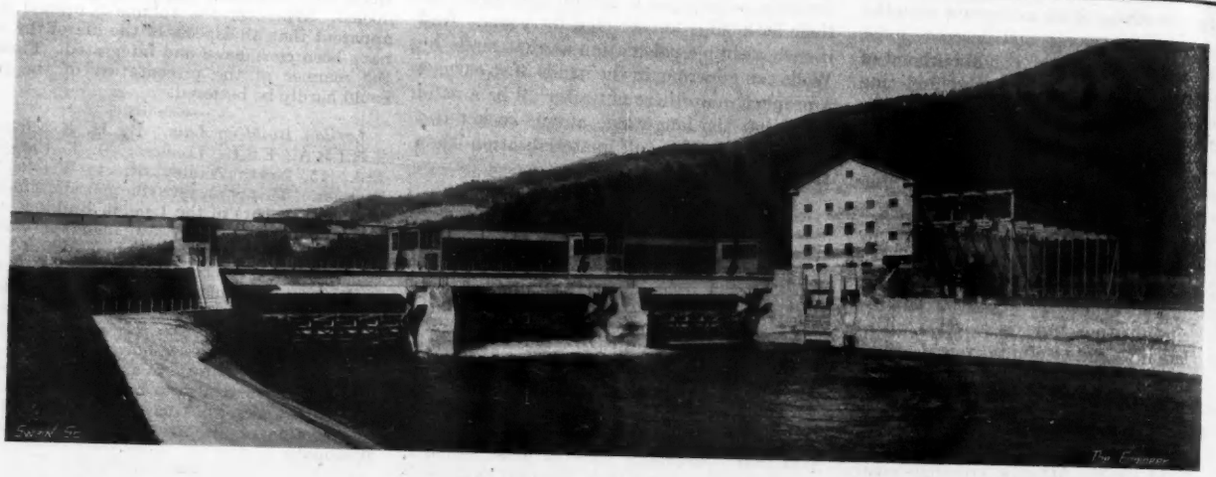
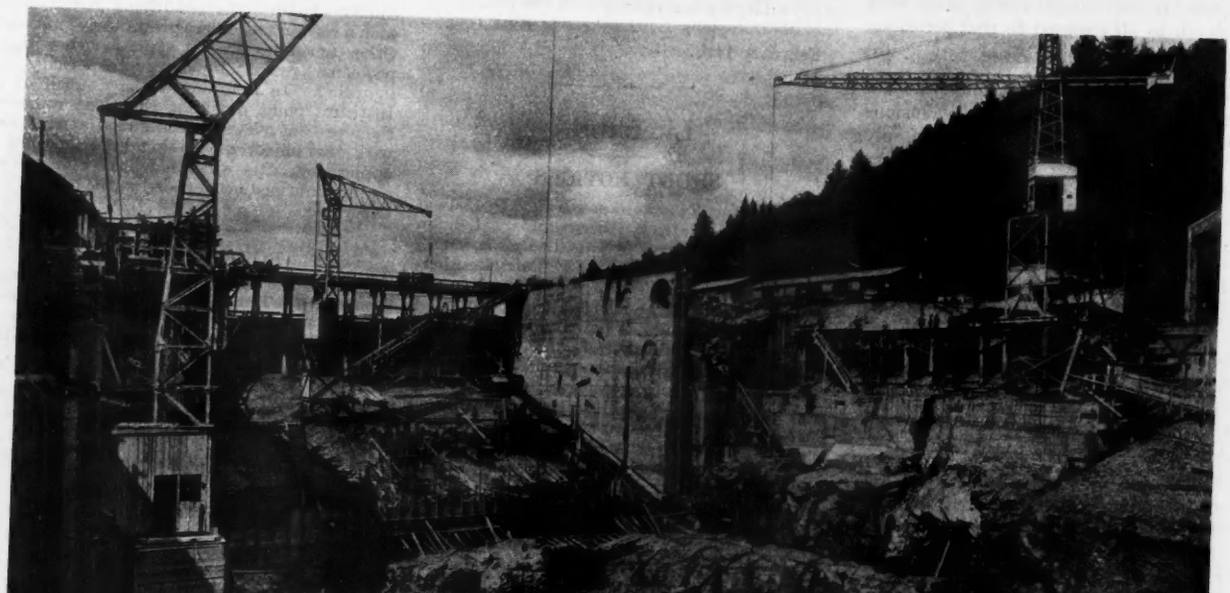
RUPPERSWIL-AUENSTEIN DAM, SWITZERLAND

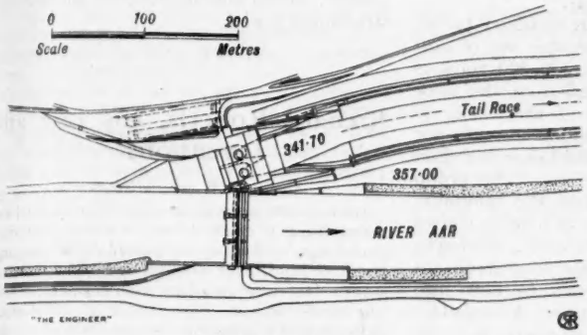




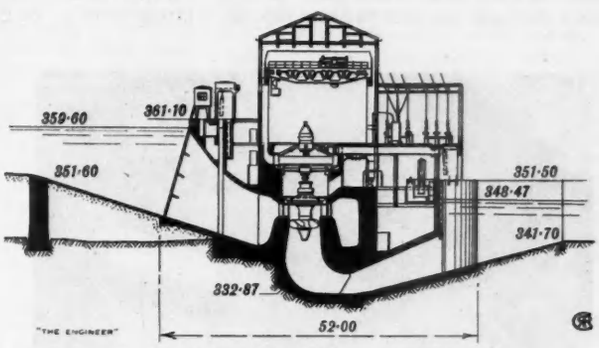
DAM AND POWER HOUSE FROM DOWNSTREAM
TAIL-RACE NEARING COMPLETION—APRIL, 1945
EXCAVATION FOR DRAUGHT TUBES—APRIL, 1944

Rupperswil-Auenstein Dam, Switzerland

WITH the object of building and operating a hydro-electric power plant, utilising the energy of the waters of the River Aar, a new power company, the Société Anonyme de Rupperswil-Auenstein, was formed at Aarau, Switzerland, in June, 1941. Dividing a capital of 12 million Swiss francs between the Swiss Federal Railways to the extent of 55 per cent, and the Swiss North-Eastern Power Company (S.A. des Forces Motrices du Nord-Est de la Suisse) to the remaining extent, the company began building in 1942 and put into operation in the autumn of 1945 a plant which is capable of generating about 210 million kilowatt-hours annually. Of this output, each of the partners has a right to an equal share. The power station generates with two groups of plant, each of 23,000 h.p. (metric); one generates single-phase current at $16\frac{2}{3}$ cycles per second for the Federal Railways and the other three-phase current at 50 cycles per second for the North-Eastern Power Company.



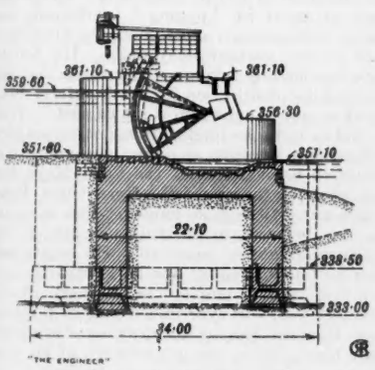
PLAN OF DAM



SECTION THROUGH POWER HOUSE

Available Flow

The plant was built to make use of the fall of the River Aar over a length of 7·3 km, between Rüchlig dam at Aarau and Wildegg.



SECTION THROUGH GATES

The catchment area above the dam site is 11,359 square kilometres and the 25 year average minimum summer flow is 120 cubic metres per second, with a maximum recorded flood, in January, 1910, of 1300 cubic metres per second. A figure of 370 cubic metres per second was taken for the designed flow through the plant. This flow is usually available for 113 days in the year. The overall mean annual flow through the plant can be taken as 275 cubic metres per second. In order to provide throughout the year a flow in the river below the plant sufficient to support fish and float small craft, 5 cubic metres per second of water is given priority over the turbine requirements. Thus, the section of the river which is by-passed by the tail-race canal is never allowed to go dry. The fall in level which is utilised varies from 12·5 m to 9·5 m, with an average of 10·75 m.

Lay-Out of Plant

The Rupperswil plant is situated almost exactly at the mid-point of the 7·3-km length of river over which the scheme extends. The dam has increased the mean water level upstream by about 6·1 m, the reservoir thus created being bounded on the right bank by an embankment protecting low-lying land on that side of the river. On the left bank little work was necessary, as the reservoir is bounded by foothills, except for a short distance near the village of Biberstein, where a marshy dip had to be filled in to a level above that of the reservoir.

The power house is built adjacent to the dam, on the left bank of the river, as shown in the accompanying plan. A view of the plant from downstream, reproduced on the opposite page, indicates the situation of the switch-yard to the rear of the power house and the arrangement of the three gates closing the main river channel.

Immediately upstream of the dam the bed of the river was dredged to form a large basin, whilst downstream a tail-race canal was excavated for a distance of 2·5 km, eventually rejoining the river about a kilometre from the downstream end of the company's concession. Below the point where the canal rejoins the river, the bed of the Aar was dredged to about 6 m depth.

DOUBLE SECTOR GATE

Construction of Dam

The dam has three gates, each with a clear opening 22 m wide. The water is held up

to level 359·6, 8 m above the cill, as indicated in the cross-sectional drawing reproduced herewith. This drawing and an accompanying half-tone engraving also show the arrangement of the gates, which are of a double radial type and were designed by the Zschokke firm, of Döttingen. The lower gate of each assembly is of the normal radial sector pattern, mounted on a frame which moves on pivots embedded in the piers. The upper gate pivots on the same points as the lower gate, but is of a bracket shape in cross section. It overlaps the lower gate. Rollers between the gates transmit the load through the lower gate to the pivots. One advantage claimed for this design is that the lifting gear can be mounted on the piers and therefore the overbridge connecting the piers can be of light construction, serving merely as a footbridge for crossing the river.

POWER HOUSE UNDER CONSTRUCTION—JUNE, 1944

The piers, abutments and cills of the dam are founded in rock, 16 m below the bed of the river. The rock foundation was designed after extensive tests had been made on a one-twenty-fifth scale model in the hydraulics laboratories of the Zürich Federal Polytechnic School, with the object of ensuring that undermining of the foundations should not occur.

POWER HOUSE

An accompanying sectional drawing illustrates the construction of the power house, which is of a type almost universally adopted for modern low-head hydro-electric plant. There are two Escher Wyss Kaplan turbines, each with a designed output of 23,000 h.p. at 100 r.p.m. The drawing also indicates the lay-out of the draught tubes, inlet gates and trash racks, the latter having bars spaced at 150 mm centres. The turbine shafts are solidly coupled to the alternator shafts. One alternator, built by Oerlikon, is rated at 22,000 kVA, and supplies three-phase current at 5700 volts, 50 cycles per second; the other, built by Brown-Boveri, is rated at 25,000 kVA and supplies single-phase current at 11,000 volts, 16⅔ cycles per second. The weight of each group is about 600 tons, and an unusual arrangement has been adopted for the pivot bearing, which has to support this weight. This bearing is housed within the top cover of the turbine, resulting in an overall saving in masonry supporting structure and reducing the lift necessary for dismantling the set, thus reducing the overall height of the building. Two overhead cranes have between them a lifting capacity of 250 tons.

An auxiliary turbo-alternator set of 530 h.p., 380–220 volts, is installed on the river side of the house, to provide current for power house and dam services. This group utilises the minimum flow of 5 cubic metres per second, referred to earlier, which is always allowed to flow into the river. A fish ladder is situated between the dam and the power house. It has two openings, one to the river and the other to the tail-race canal.

Upstream, in front of the building, are the intake control arrangements, whilst downstream, on a platform above the tail-race, is the outdoor high-tension distribution gear.

Current from the single-phase alternator is stepped up from 11 kV to 66 kV and 132 kV by two transformers, and is led to the nearby Rupperswil sub-station of the Federal Railways. Current from the three-phase machine is transformed from 5700 to 50,000 volts, and is fed through a short overhead line to the 50-kV network of the North-Eastern Power Company.

Underneath the platform for the distribution gear are arranged two liquid resistances, each of which is capable of absorbing the total output of one alternator. Should power surges occur in the distribution networks, resulting in tripping the emergency arrangements, the load is automatically transferred to these resistances, allowing the necessary adjustment of the flow through the turbine to be made gradually, and avoiding sudden alterations in the level of the tail-race canal.

For possible future river navigation space has been reserved on the left bank of the river, upstream from the power house, for two locks, 75 m long and 9 m wide.

TAIL-RACE CANAL

Except for a short length, the tail-race canal was entirely excavated from the gravel of which the left bank of the river is composed. An engraving on page 174 illustrates the canal immediately to the rear of the power house. The canal is of trapezoidal section, with a bottom width of 24 m. The banks below water level have a slope of 1 to 2½, and above water level 1 to 1½. The part of the banks immediately below water level is protected by concrete and stone, but the remainder of the canal has no protection, except that the portions out of water are covered with soil and sown with grass. The depth of water in the canal when the turbines are working to full capacity and the flow is 355 cubic metres per second is about 6·5 m, with a velocity of 1·3 m per second.

Material excavated from the canal and from the bed of the Aar totalled 2¼ million cubic metres. The materials were all utilised in building the upstream embankment along the right bank of the river, in filling low-lying ground, and in making concrete for the constructional works.

Richard Roberts, His Life and Inventions*

By H. W. DICKINSON

BIOGRAPHY is divisible immediately into two main kinds: that based on contemporary knowledge and that on posthumous inquiry; the first kind, even though it be of little substance, has a value all its own that the second can never attain. In the case of Richard Roberts it is regrettable that so little of the first kind has survived, but what little is known has been embodied with the outcome of numerous inquiries in the present paper. Like so many others of his time, he was born, in 1789, in humble circumstances in a remote part of the country and owed little to scholastic education.

His birthplace was the Tollhouse in the township of Carreghofa, in the parish of Llanymynech, Montgomeryshire. His father, William Roberts, combined the craft of shoemaking with the duties of tollkeeper.

When Richard had got to an age when boys in his position had to begin to earn their living he is said to have started work with a boatman on Telford's newly opened (1798–1805) Ellesmere Canal, a branch from which, 12 m long, extended from Frankton to Llanymynech. The construction of this canal brought many contacts with the great world outside which cannot have failed to influence the boy.

Meanwhile his skill in making a spinning wheel for his mother was talked about, as will happen in country places, and came to the ears of the management of the Llanymynech limestone quarries, where two of his younger brothers, Tobit and William, were subsequently employed. As a consequence, Richard made his real start in life by obtaining employment there to assist in "jigging" or drawing the wagons of limestone, and to note the number of loads of lime carried away daily. His fellow-workmen, having taken a liking to the lad and knowing his predilection for handicraft, clubbed together and bought him a kit of tools. With the aid of these he made, among other articles, another but superior spinning wheel; this he is said to have raffled at the Cross Keys Inn, Llanymynech (or was it the Cross Guns, Pant, a mile away ?) to raise money. This spinning wheel is believed to be still in existence, but its whereabouts is unknown. He must have been a "lad o' pairts," for he is said to have attracted the attention of Robert Baugh, assistant road surveyor under Telford; Baugh gave Richard lessons in drawing during his spare time. This, the groundwork of an engineer's training, was invaluable to him subsequently.

Roberts worked at the quarry till he was twenty years of age, attaining eventually the status of a quarryman, when, feeling within him the desire and the capacity for the career of a mechanic, he left his job and went to Bilston, Staffs, some 50 miles away, and there found employment as a patternmaker at Bradley Ironworks, then being carried on by the executors of the well-known ironmaster, John Wilkinson.

In 1814 he decided, like so many young men before and since, to seek work in the Metropolis. He made the journey on foot, as he was well

* The Newcomen Society, November 13, 1946.

able to do, for he had a splendid constitution. Arrived there, he tried first to get a job at Holtzapffels, the well-known mechanicians in the Haymarket, but there did not happen to be a vacancy. He went on to Maudslay's works in Lambeth and was fortunate enough to get a start. Maudslay must have seen something in him because he could not have brought with him testimonials of any particular value. Roberts remained with the firm for two years in the capacity of turner and fitter, years, without doubt, of rapid advance in mechanical knowledge, for the Maudslay works were in the forefront in Great Britain in methods, tools and design. The work that was going through the shops was, *inter alia*, the building of the table engine, patented by Maudslay in 1807. Roberts could not have failed to have learnt much about steam engines.

Roberts decided to set up in business for himself, choosing Manchester, the active seat of the cotton trade, as his venue. In 1816 he took a workshop in Deansgate, his outfit comprising a hand lathe and a drilling machine; his private house was 5, Water Street. The house exists no longer, as it was blitzed in December, 1940. There was a slump after the European War, but there was plenty of work to be done in his particular line.

He had now reached the age when experience shows that a man attains to full inventive capacity. His reputation began to spread, and it is said that the Borough Reeve of Manchester—for the town was not then incorporated—came to him to ask him to make a meter to measure large volumes of coal gas. The problem of measuring domestic consumption by the wet gas meter had only recently been solved by Clegg and Malam; this task Roberts successfully accomplished by similar means.

Machine Tools.—In the following year, 1817, he designed and made a machine for planing metal. Quite a number of inventors, about the same time are credited with the invention of a machine for this purpose. There is no doubt that the idea arose in many minds and it was only a question of how best to achieve the intended purpose. Matthew Murray is said to have made such a machine in 1814 for planing the faces of his D-valve, patented in 1802, but to have kept it secret, and we have no details of it. George Rennie said he made as early as 1820 "a planing machine with a movable bed, urged by an endless screw and rack, and furnished with a revolving tool." William Fox, of Derby, made a machine in 1821 for planing the wrought or cast iron bars used in lace machines; its capacity was 22in by 10½in by 12in deep. It has been stated that a tool had been made for producing the longitudinally grooved drawing rollers required in cotton spinning. Such a tool might have given a hint, but only a hint, to Roberts; it is a matter for regret we know so little about the development of this important tool. The distinguishing merit of Roberts' machine is that it embodied features that have been retained permanently—a holed bed sliding on vee guides and a cross slide adjustable vertically to hold the tool. Motion was given to the bed by chains, worked by hand by a capstan head. His machine has been preserved and is in the Science Museum, South Kensington. It certainly bears marks which indicate that nothing but handwork went into the making of it.

The planing machine was followed by other tools, or additions to tools, such as the back-geared lathe headstock. This was a valuable addition to Maudslay's previously invented screw-cutting lathe, in that it increased its capacity and rendered it capable of heavier cuts. About the same time, 1820, Roberts improved the screw-cutting lathe. Instead of change gears he had a divided plate with concentric rings of teeth with any one of which the leading screw could be made to engage. This original lathe remained in use for forty years in successive workshops and has eventually found its way to the Science Museum. He also produced about this time an improved wheel cutting engine on the lines of that used by clockmakers.

We have definite knowledge of what Roberts was doing in 1821 from an advertisement that he inserted in the inaugural issue of *The Manchester Guardian*, May 5, 1821. His workshop was at Pool Fold, New Market Buildings, *i.e.*, the place previously mentioned. He advertised that he could cut out any kind of gearing up to 30in diameter and in any material, also screws of any pitch and diameter, on his "Improved Screw Engine."

We get a glimpse of Roberts in August of the same year when he was visited by Joshua Field. This is so informative that we venture to quote from it at length.[1]

"... we went to Mr. Roberts manufactory, a man who formerly worked with us. He is a good workman & has good ideas with many very good tools. His shop is in a bad part of the town and extremely shabby outside. On the ground floor are 2 forges and some lumber but upstairs he has good lathes, screw engines, cutting engines; with the latter machine he does a great deal of work in cutting wheels for the cotton spinners both in brass & iron. His machine has the wheel held as in a lathe but not turned, being held centrally by ring on an arbor, his cutters are made of steel plate turned to the shape of the tooth and teeth cut like a saw very coarse and cut given to them by a steel cutter in a lathe. He has 3 small bed lathes and one large one of abt. our screw engines bed lathe, with a slide rest made (?) the long slide hangs on the front so that he looses no diamr. The slide can be moved along by some wheels from the mandril at various velocities changable by a pinion working into 5 or 6 rings of pins on a face chuck. The pinion moves into any row of them. He puts the back centre screw with the cylinder the same length. He has just made a machine for driling, very well finished, but is by no means better than many at work which do not cost half this.

"The dividing engine of this wheel cutting machine is a worm wheel & screw like Ramsdens, a double threaded screw, and the wheel and screw both cut at twice, which he concives divides the errors. He then has a wheel on the screw and a wheel on fixed pin near. These two wheels are connected by an intermediate wheel—by proportioning these two wheels he reduces every division wanted to 1 turn of the last wheel which has a stop. Having a vast number of wheels which both fit this machine & the screw engine, he is seldom at a loss for any division and is making a new engine in which he intends to form the intermediate wheel of 2 wheels of different teeth which gives a new variety.

"In his large lathe he drives by a strap on a 5 or 6 sized drum and has contrived the slow motion so that the strap is always on the same drums thus somehow. Thus the drum runs alone upon the mandril & is fixed by a pin when the quick motion is wanted and the pinion &c. thrown out. He is making a turnstile like that on Waterloo Bridge for a Bridge here and a machine for making reeds. He employs about 12 or 14 men in rather a crowded shop. His machinery is turned by 3 men. Has drums above hanging frames exactly the same as at Margret Street except his shafts & hanging frames are lighter. Pays his men from 26s. to 30s. Hoole is there and knew me. His men for turning the wheel 11s."

Although Field does not mention it, Roberts about this time introduced templates for the manufacture of cotton machinery, in which there is such a large amount of repetition work, such as spindles. It is not certain whether this was original with him or had been suggested by his London experience. He is also said to have introduced plug and collar gauges as workshop appliances, and to have been the first to do so, but we have been unable to confirm this.

Roberts never forgot his early efforts to cultivate his mechanical aptitude and to acquire knowledge of mechanics. We find, consequently, that he was to the fore in establishing the Manchester Mechanics' Institute at the time when such institutions were being founded up and down the country, owing to the advocacy of Dr. George Birkbeck. Roberts, himself, always striving to enlarge his own knowledge, did not fail to take advantage of every opportunity of doing so. We find that he sought admission as an ordinary member of the Literary and Philosophical Society of Manchester and was elected on April 16, 1823. The certificate of membership, with seal of the Society, signed, among others, by John Dalton and William Henry, is preserved at South Kensington. This opened out to him intercourse with other engineers and scientific men, of whom there was quite a galaxy there during this time; among them, besides Dalton and Henry, we may mention Fairbairn, Nasmyth and Whitworth. We shall learn later of contributions made by Roberts to the "Memoirs" of the Society.

At some date, about 1822 or 1823, Roberts entered into partnership with a certain Hill, under the title Roberts, Hill and Co. What led up to this and who his partner was we do not know. Their address is given in Baines's "Directory" of 1825 as 33, Faulkner Street, near Mosley Street, and their business is described as that of power loom makers; Roberts's private house was at 23, Faulkner Street. Up to this time he had not patented any of his inventions, for one reason possibly, the great cost—about £120—of doing so, and possibly because his inventiveness has so far taken the direction of making tools to expedite his output rather than of making a manufacture of them. His business was now largely concerned with machinery for the cotton industry, and thus for the first time he seems to have turned his inventive faculties in that direction. Roberts's first patent (November 14, 1822, No. 4726) was for improvement in reeds for looms; this has been mentioned by Field above.

Self-Acting Mule.—In 1824 a situation arose which led to the invention with which Roberts's name will ever be associated, *i.e.*, the improvement of the mule by rendering it self-acting. The mule was invented by Samuel Crompton in 1779; it was a hand-worked machine having a cycle of three consecutive operations: drawing out simultaneously possibly a hundred loosely twisted slivers by a carriage, twisting them to form yarns and then returning the carriage as the yarns were being wound on cops. The machine had been mechanised as far as the spinning and the winding were concerned, but the to-and-fro motion was still effected by hand. Many attempts to devise mechanism to effect all the operations mechanically had been made, *e.g.*, by Kelly, of Lanark, and Strutt, of Belper, but with only partial success. A strike for higher wages among the spinners at Stalybridge in 1824 precipitated matters. Mr. Ashton, a prominent cotton spinner there, interviewed leading mechanics to find out if they could effect the desired improvement, but all declared it was impossible. He then called on Roberts, who said that he understood nothing about the mule, which was doubtless true, and would not commit himself. The strike continued and a deputation headed by Mr. Ashton called once more on Roberts, who meanwhile had been pondering over the subject. He was afforded opportunities of studying a mule installed in his own works and eventually succeeded by means of the "faller wire" in effecting what was wanted; this invention was embodied in his celebrated patent of 1825 (March 27th, No. 5138). Roberts's mule had much prejudice to overcome and only came into use slowly.

In 1826 Roberts was induced to go to Alsace, France, to plan and arrange the machinery for a new factory built at Mulhouse by André Koechlin et Cie., well-known cotton spinners. He spent a couple of years there and, as it was his first introduction to a foreign country and language, we should have liked to have known his reactions to his new surroundings as well as details of the actual work he did, but we have no record.

His reputation for inventiveness and resource might now be said to have been firmly established, so that it is no wonder that many eyes should have been upon him, among them those of Thomas Sharp, who, with this brother, Robert Chapman Sharp, had established a works for making textile machinery as far back as 1806; in 1823 a third brother, John,

[1] "Trans.," XIII, 24–27.

had been taken in. The style of the firm was Sharp Brothers and their address was the Globe Works, Faulkner Street, *i.e.*, close to Roberts's works. In 1828 Thomas Sharp offered Roberts a partnership and it was accepted, the firm becoming known as Sharp, Roberts and Co., subsequently to acquire a world-wide reputation. The firm had been doing a large trade and this opened out wide scope for Roberts's energies. The firm took up the manufacture of the self-acting mule and are said to have expended £12,000 in bringing it to perfection. The final touch was added by Roberts in his patent of 1830 (July 1st, No. 5949) by the invention of the winding quadrant, an ingenious device that has never been superseded.

In 1830 the opening of the Liverpool and Manchester Railway directed the attention of engineers, Roberts among them, into the new channel of activity, that of the construction of locomotive engines. He took up engine building and patented in that year, 1832 (April 13th, No. 6258), many details, one of which was a piston valve to the cylinder. The first locomotive, the "Experiment," that the firm built for the railway in question was a 2–2–0; it had vertical cylinders, bell cranks and this piston valve, but they gave trouble; in fact, both this engine and the similar "Hibernia," built for the Dublin and Kingstown Railway, were failures, so much so that Roberts dropped the subject for two years.

Meanwhile, he tried his hand at a steam carriage, embodying several details, including the "jack-in-the-box" or differential drive on the back axle; this, though frequently attributed to Roberts, was not original with him and had already been used by engineers in this country as well as on the Continent. In common with other inventors of such carriages, tribulation attended the trials and they had an unsuccessful issue. In 1837 he resumed locomotive building. He adopted the 2–2–2 design that had in the interval become standard. There is no need to describe the engines, as this has been done repeatedly, for they were made for the leading British and Continental railways. They were renowned for excellence of detail and finish, compactness and capacity for doing hard work.

As we have seen, Roberts had been mixing for some years with the intellectuals of Manchester and he now widened his horizon by seeking election as a member of the Institution of Civil Engineers. He was proposed by his friend, William (afterwards Sir William) Fairbairn, "on account of his extensive scientific attainments & eminent practise as a Civil Engineer." The reasons submitted could hardly have been bettered, although the order in which they are given might have been reversed. The proposal was backed by Joshua Field, James Simpson and William Cubitt; his election took place on March 20, 1838, James Walker being President.

A misfortune befell Roberts in the loss of his partner, Thomas Sharp, who died in 1842, which led in May of the following year to the dissolution of the partnership. Roberts retained the Globe Works under the style of Richard Roberts and Co., while the remaining partners established the Atlas Works, which they devoted particularly to building locomotives, for which they became world famous.

For the amusement of his children, Roberts is said to have made a "loop-the-loop" toy to illustrate centrifugal force. It was in the form of a railway with a little carriage which could be filled with water; this, running down an incline, gathered speed, turned upside down without spilling any water and ran up an incline on the opposite side. One of these toys was preserved in the collections of the Manchester Literary and Philosophical Society and was destroyed only in the 1941 blitz. Sir William Bailey[1] (1838–1913) tells us that an actual railway was "constructed upon a scale large enough to convey a living traveller" and exhibited at the Old Hall of Science, Manchester. A lithographed sketch of it has been preserved and the same writer says that such railways were made for "the Zoological Gardens, Cheetham, and afterwards at Liverpool and other places." We believe this to have been the origin of this scientific amusement, for it has had no serious application.

Benjamin Fothergill had been acting as manager of the Globe Works during Roberts's ill-health, and it was about February, 1845, that he and Robert Graham Dobinson were taken into partnership. The entry in Slater's "Directory" for 1848 is as follows:—"Roberts, Fothergill and Dobinson, engineers and tool and machine makers, GLOBE WORKS, 79, Faulkner Street."

On November 4, 1845, Roberts gave evidence before the Commission appointed to inquire into the gauge of railways. He stated that he discovered the want of room in the locomotive for the narrow gauge in the first engine he made and wrote "several letters to Members of Parliament so far back as the year 1831 . . . suggesting that engineers should be consulted as to the best width of gauge and the best space between the gauges of the two lines." He advocated 5ft and 6ft respectively. When the Irish Railway Commission were fixing the gauge for Ireland and 6ft was proposed, he wrote to *The Railway Times*, September 8, 1838, advocating a gauge between 5ft and 5ft 4in preferably the mean. This seems to have had weight, for in his evidence he says: "I have a letter of General Pasley's in which he writes to me to say that they have fixed upon my gauge—he chooses to call it mine for Ireland. . . . I think a gauge better than 5ft 3 could not be selected." He also advocated a Royal Commission to make a "national survey" of all mail lines, but no notice was taken of it.

(To be continued)

[1] See Bailey, Sir W. H., "Switchback Railway," *Manch. Lit. and Phil. Memoirs*, April 4, 1902. This engineer had a profound admiration for Roberts's genius and kept his memory alive in many ways, cf., *Manchester Weekly Times*, March 30, 1878. He had a biography of Roberts in prospect at the time of his death.

High-Frequency Induction Heating*

By E. MAY, B.Sc., A.C.G.I., A.M.I.E.E.

THE development of industrial equipment for heating metals by high-frequency induction has given the metallurgist and the production engineer an entirely new tool with revolutionary possibilities. By such means, virtually any amount of heat can be applied to any portion of a metal object, and at a higher rate than by any other commercial process. Nevertheless, high-frequency heating has limitations which must be clearly recognised, no less than its remarkable advantages. To mistake its proper sphere may be just as bad as to ignore its true possibilities.

High-Frequency Power Sources

Most applications of induction heating require a frequency higher than that of the supply mains; some form of frequency converter is therefore necessary.

The inductor alternator is now widely used for frequencies up to 10,000 cycles per second; the upper limit is at present about 50,000 cycles. Power ratings up to 1800 kW at 1000 cycles and 250 kW at 10,000 cycles have been built. Melting, through heating of billets and bar-stock, and the heavier surface-hardening applications form the principal loads for these machines. Small sets, up to 250 kW or so, are sometimes built as two-bearing machines, with motor and generator rotors on one shaft; separate machines, directly coupled, are used for larger sets. The excitation of the alternator can be done from any convenient d.c. source, *e.g.*, a generator or a rectifier; grid-controlled rectifiers, thyratrons are employed in electronic voltage-regulator equipment having high-speed response.

The demand for power at frequencies from 100 kilocycles or so up to several megacycles per second is now being met by the high vacuum thermionic triode valve. Used as a "class C" power oscillator, it converts d.c. power at several kilovolts to high frequency a.c. power with a conversion efficiency of 75 per cent. It is the most versatile of all the types of generators at present available, but its *métier* is unquestionably the surface hardening of components requiring a relatively thin case. Output power ratings from 5 kW to 100 kW are at present available.

Lastly, mention must be made of the inverter, a new type of generator which may become widely used in a few years' time. This relaxation oscillator employs grid-controlled mercury-vapour rectifiers, or alternatively ignitrons, and has a conversion efficiency of 90 per cent or more. Unfortunately, the frequency limit is at present low (about 2000 cycles per second), and there are difficult technical problems to solve before it can be regarded as suitable for wide-scale use.

In many cases the kind of h.f. plant to use is immediately obvious from power or frequency requirements; in others any one of several kinds of plant could be used. For example, if a large amount of metal is to be through-heated per hour (corresponding, say, to h.f. power rating of 100 kW) and the work-pieces are bigger than ½in diameter, then the obvious choice would be motor equipment. Again, if steel spindles or shafts are to be surface-hardened to a depth of 0·02in or 0·03in, then valve type generators would be used, because no other equipment is capable of generating a sufficiently high frequency (500 kc or so) for this shallow case to be realised.

On the other hand, many localised through-heating jobs, including annealing, hardening, brazing and stress-relieving, may be done equally well, using spark, valve, or alternator sets. For supplying a single work-head, or a localised group of work-heads, the valve set is generally the most suitable in such cases, for power ratings up to 20 kW. Where it is required to have induction heating stations at a number of points in a shop, then the alternator offers the great advantage of easy h.f. power distribution to the several points from a remote substation, using lead-covered or braided concentric cable. Although some such distribution is not impossible with valve oscillators, it is very much more difficult.

Applications

We will now consider some of the many ways in which high-frequency induction heating has been applied to industrial processes.

Melting.—The earliest use of high-frequency heating in industry was concerned with melting. Melting furnaces range in size from units for melting a few ounces of gold or platinum, up to steel melting units capable of holding and melting 8 tons in three hours. For the small-sized melting units, such as are used in laboratories, and for melting of small amounts of precious metals and other small production melts, the spark gap oscillator is used, and recently the valve type generator has been used for this purpose. The motor generator set is by far the most widely used for induction melting, on account of its higher efficiency, and because the stirring effect is more pronounced and the size of furnace is not so limited as in the case of the other type of generators.

As a rough approximation, units ranging from 50 kW to 1250 kW will melt from 250 lb to 300 lb of steel per hour for each 100 kW of generator capacity, but on account of the lower efficiencies of the small sized generators and furnaces the overall consumption per ton will vary from 900 kWh in the case of a 50 kW unit to about 600 in the case of the largest units. These consumptions correspond to overall efficiencies of about 40 per cent for the small units and 60 per cent for the large furnaces. The difference between the input of energy to the motor and that appearing as heat in the molten metal is made up of the losses in the motor-generator itself, the condensers and conductors, the I^2R loss of the coil and the radiation and conduction losses from the crucible itself. These vary greatly according to size of generator and furnace,

* Abstract of Paper, Institution of Production Engineers, Yorkshire Section. Oct. 7th, 1946.

and the time of melting, and explain the wide variations in overall efficiency.

Surface Hardening.—Of the more recent applications of induction heating, perhaps the most fascinating one deals with surface hardening. This is possibly the widest field of application, as it has numerous advantages over other methods of case hardening; there is a minimum of distortion, as the heating is confined to the surface layers and the strength of the core is generally sufficient to prevent relative movement; the steels employed are normally low alloy or plain carbon since depth of hardening is not necessary and water quenching is readily applied; also there is no appreciable oxidation, as the time cycle is so short—frequently of the order of one or two seconds. This means that a finished machined part can be hardened without the need for elaborate subsequent cleaning operations. As the hardening conditions can be predetermined and duplicated with great accuracy, absolute consistency can be guaranteed from part to part, and this can be attained with relatively unskilled operatives. Among the other incidental advantages may be cited the absence of decarburisation and the possibility of localising the hardening without the need for such cumbersome operations as copper plating or other methods of stopping off. It should be remembered that it is primarily a mass production method. It would probably prove uneconomical to treat small quantities of many different parts, since it might be found that the time taken for changing inductors and quenching equipment would rule out this method of surface hardening.

Turning to the depth of case, it has been shown that frequency plays a large part. Equally important, however, is the rate of power input, since if this is too low the case effect will be destroyed on account of conduction of heat to the core. For large objects the rate of heat conduction is of the order of 5 kW per square inch when at the hardening temperature, so that the rate of power input must exceed this to produce an effective case. Generally, it is found that power inputs of from 8 kW to 15 kW per square inch are required and the heating time is of the order of one to four seconds. If a part can be progressively hardened by passing it through a coil, as in the case of a shaft, then it is only necessary to heat a small portion of the surface at a time, requiring, of course, a relatively small power input. Quenching is then done by means of a water spray.

When it is considered that the material to be hardened is in the gamma range for only a fraction of a second, it is amazing that the carbides can go completely into solution in that time. The original condition of the steel is, therefore, of the utmost importance in this connection. The author has seen an alloy steel in the spheroidised condition heated to 850 deg. Cent. and quenched, and the material has not changed in hardness due to lack of solution of the carbides. The carbide size must, therefore, be fine, preferably in the sorbitic condition, failing which a fine normalised structure is the next best. Since the heating time is so short it is possible to exceed by 100 deg. or even 200 deg. Cent. the normal hardening temperature, to get more rapid solution of carbides, without producing any ill-effect on the steel. Care, however, must be taken not to produce retained austenite.

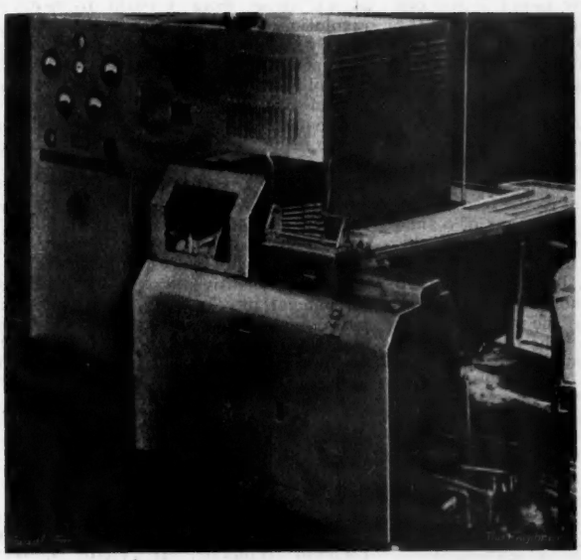
A wide range of parts is being satisfactorily treated by this method—cam shafts, crankshafts, gears, spline shafts for small motors, gudgeon pins, pump parts, sprockets, tractor pins, bearing surfaces, knife-edges, and so on. The hardening of internal surfaces, although it presents more difficulties than the treatment of external surfaces, is being satisfactorily carried out with this type of equipment.

An automatic equipment for surface-hardening ¾in diameter round and splined shafts is illustrated herewith. Only about 3½in of the shaft length is treated, the case depth being 0·03in. Driving motor, camshaft, oil pump and water filter are housed in the fabricated steel base; the work-head transformer and the water spray-quench valve are located in a brass screening box above the mechanical gear. The magazine, to the right of this box, is loaded with shafts by hand. Each shaft in turn is taken automatically from the magazine, fed progressively through the "concentrator" and its integral quench spray, withdrawn again and discharged on to a roller conveyor. A 20-kW valve oscillator, nominal frequency 400 kc, provides the h.f. power, and the production rate is 300 shafts per hour. The shafts are finish-machined before this heat-treatment, and proceed therefrom to an assembly operation. This particular application of induction surface-hardening showed remarkable economies compared to the method previously used, the capital cost of the equipment being recovered within a few months of installation.

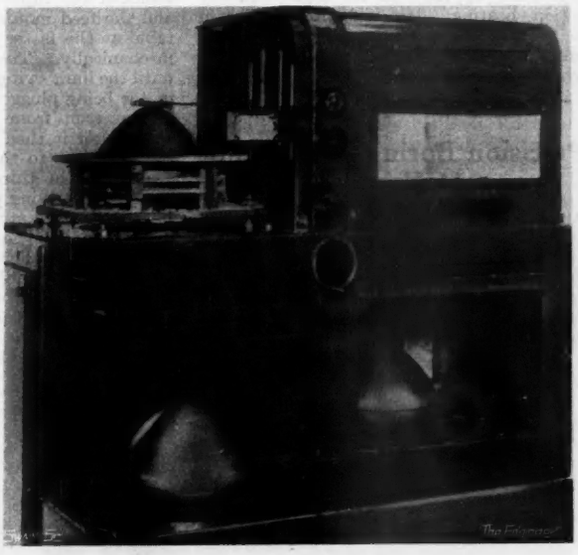
Through-Heating.—Many different applications fall under this heading: localised through-hardening of components, continuous progressive through-hardening and tempering of bar-stock, localised and entire heating of billets, bars, hollows, &c., for hot-working, and so on.

The principal advantages accruing from the rapid heating and mechanised handling (the essence of the induction method) are: (1) Scale formation is greatly reduced, resulting in considerable saving in steel, and, in hot-working, increased life of tools and elimination of "stickers." (2) Accurate automatic control of heating time and power gives perfectly consistent results. Closer tolerance can be maintained, and often the rapid heating gives a much finer grain and a better product. (3) Greatly improved working conditions.

The time required to through-heat a section will depend upon the degree of uniformity desired between surface and centre temperatures: obviously the lower limit is set by incipient melting of the surface. There must be some temperature gradient from surface to centre while energy is being supplied to the steel, but this disappears within seconds of leaving the coil, in the case of billets up to several inches diameter. A good rule for through-heating time for round steel bars and billets is $25 \times d^2$ seconds, where d is the diameter in inches. Bars up to an inch or so diameter can be heated at speeds about twice this rate, but the maximum possible heating speed is not necessarily always the most suitable when all factors are considered. You will notice that, since both heat content and heating time are proportional to d^2, the upper limit of kW loading per inch length of billet will be approximately constant, independent of billet diameter. Using a constant of 25 in the expression for heating time, this loading is approximately 5 kW per inch for steel bars and billets heated to 1250 deg. Cent. and includes coil loss and radiation loss.



SURFACE HARDENING STEEL SHAFTS



ANNEALING RIM OF PRESSING

A machine for annealing the rim of a deep-drawn pressing, prior to a spinning operation, is illustrated above. There are two heating stations, and pressings are raised into the coils by means of compressed-air rams. Unloading and reloading are taking place at one station while the other is heating, but both coils are continuously energised. The cycle time is determined by motor-driven camshaft, but the rams will not operate until the safety doors are closed. Pneumatic door locks make it impossible to close a door if, through some delay, the door has not been closed early enough for the pressing to be held up in the coil for the correct length of time. The unit will anneal steel pressings at any desired rate from 150 to 450 per hour.

Costs and Conclusions

Valve generators cost approximately £200 to £80 per kW of output, for ratings from 5 kW to 50 kW, respectively. The running costs must include valve depreciation and, where applicable, valve cooling water. For example, a 20-kW output set costs about 5s. per hour to operate at full load, exclusive of labour. Complete motor-generator equipment for 10 kc costs from £100 to £25 per kW, for ratings from 25 kW to 500 kW respectively. This includes starter, isolator, voltage-regulator, output contactor, and series condenser. Running costs

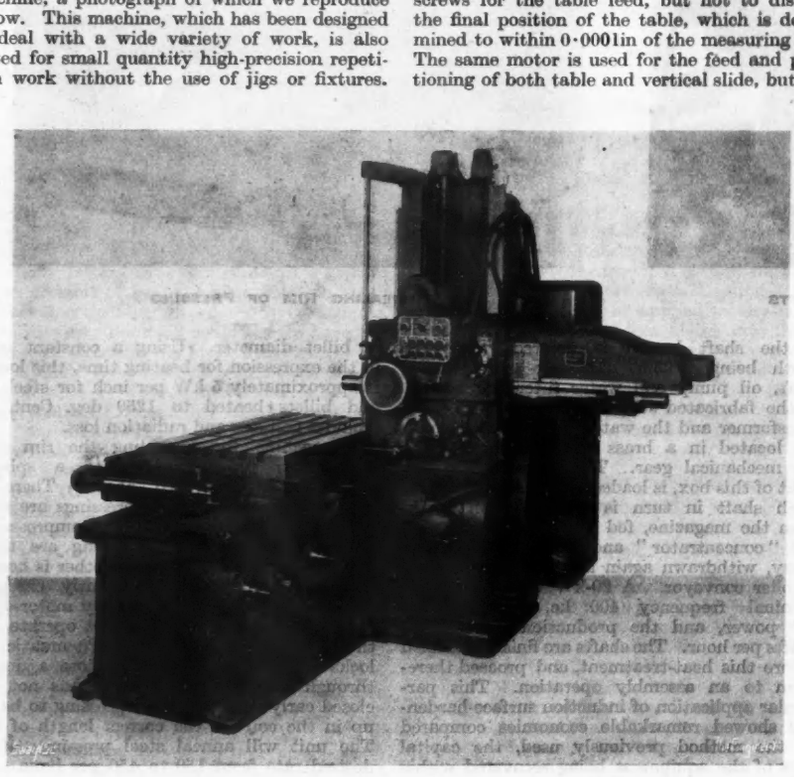
are lower per kW than for valve sets, actual mains energy input being the only significant item.

The through-heating of steel bars and billets to 1250 deg. Cent. is effected, using motor-alternator equipment, with an expenditure of 1 kWh for about 5 lb weight of steel heated. Surface-hardening costs can only be quoted for individual cases; *e.g.*, the continuous surface hardening of ¾in diameter bars for their full length to a depth of 0·3in corresponds to an expenditure of about 200 kWh per ton. Steel melting costs have already been quoted as varying from 600 kWh to 900 kWh per ton.

There is often a tendency to try to apply a new method too widely; on the other hand, there is sometimes reluctance to initiate a perfectly suitable application. Both extremes can be avoided by making available to production engineers information on the principles and practice of new methods as they develop. The surface-hardening of regular sections, localised hardening and annealing, rapid through-heating for hot-working, through-hardening and tempering of bar stock, localised heating for brazing and soldering, and the melting of high-grade steels and alloys are all legitimate applications for high-frequency induction heating. Its widespread use in these fields is certain, especially where full advantage can be taken of the mechanisation to which the method is so well suited.

A Precision Boring and Milling Machine

PARTICULARS have been received from Alfred Herbert, Ltd., Coventry, of the new Devlig No. 3B "Jigmil" precision boring and milling machine, a photograph of which we reproduce below. This machine, which has been designed to deal with a wide variety of work, is also suited for small quantity high-precision repetition work without the use of jigs or fixtures.



OPERATING POSITION OF THE NO. 3B "JIGMIL"

Its table is 48in long by 30in wide, and has a horizontal travel of 48in. Work within the dimensional capacity of the machine up to 2 tons in weight can be accommodated.

A particularly interesting feature of the "Jigmil" is its electric control mechanism, by the use of which the table and spindle head can be automatically positioned to a high degree of accuracy. End measuring rods are used in conjunction with this mechanism. With the rods in position and the control levers set in accordance with the unit to be moved, pressure on a push button on the control panel automatically and quickly positions the slide concerned. When positioning under automatic control the slide first moves under rapid traverse to the required location. It then reciprocates about the limit determined by the length of the measuring rod at successively lower feeds until it locates and stops within a stated accuracy of 0·0001in of the required point.

This automatic positioning of either the table or spindle head is determined by a selector lever on the side of the bed and the setting of a four-position selector switch.

Assuming that it is required to position the table, the selector lever is moved to the "table" position. On pressing the automatic position button the saddle is rapidly traversed to the right until the end of the measuring rod hits the finger on a limit switch lever. This closes a contact button in the limit switch, de-energising the magnetic starter for the rapid traverse motor plugging it to a stop in accordance with a time delay pre-set on another relay to permit the saddle to overrun by from 0·020in to 0·030in. When the plugging current is removed the rapid traverse motor is cut out and the feed motor is energised, reversing the table at the faster of two feed rates, selected mechanically. The table moves to the left until the limit switch is again operated, the feed motor being plugged to a stop when the table has overrun from 0·005in to 0·010in. The feed motor is then reversed at low speed, the saddle moves to the right operating the limit switch for the third time. This action again applies a reversing potential to the feed motor, plugging it to a stop and, by means of a time delay relay, allowing it to reverse a few revolutions to release the tension in the gears and lead screws for the table feed, but not to disturb the final position of the table, which is determined to within 0·0001in of the measuring rod. The same motor is used for the feed and positioning of both table and vertical slide, but the latter is operated by a finer pitch lead screw and the overrun is reduced by a corresponding amount.

The time required to position either slide for a distance of 6in is stated to be less than 10 sec. The mechanism is so designed that neither the dial indicator nor limit switch can be damaged by excessive pressure.

When the slide is in position it is locked by movement of a hand lever, which also switches off the motor driving the positioning mechanism. This hand lever and the motor switch are interlocked to prevent the mechanism being used when the slide is fixed. The table and head locking levers each operate an arrangement of toggles and levers which, whilst giving a good locking pressure, do not in any way disturb the setting of the slides when coming into effect.

The table can be retracted on the machine saddle for a distance of 16in, to permit tool setting with a minimum of overhang from the spindle nose and to facilitate work inspection and tool adjustment without disturbing the main setting. Automatic retraction and return of the table is effected through two push buttons. On its return movement the table stops in its initially set position, where it is automatically locked. This position can be preselected and accurately adjusted as required with the assistance of a micrometer.

The spindle is chain driven from a 3¾–7½ h.p. two-speed motor through a gearbox, giving a range of spindle speeds from 23 to 1200 r.p.m. Automatic feeds to the spindle are transmitted through a gear train driven off the main spindle. This design provides feeds in inches per revolution, irrespective of the spindle speed in use, in six steps, from 0·001in to 0·012in per revolution. The spindle can be traversed rapidly in either direction at a speed of 90in per minute by movement of a joy-stick control lever, which is also used to engage the feed motion.

The automatic feed to the table and the slide of the machine is transmitted through a quick-change gearbox on the side of the bed. Twelve feeds from 0·3in to 15in per minute are available. Two traverse speeds are provided to the horizontal and vertical slides, half depression of a single push button giving a slow rate and full depression a fast rate.

A comprehensive system of electrical and mechanical interlocks is incorporated in the machine to protect the automatic mechanisms, and, as is indicated in the illustration, the various controls are well grouped for quick and easy operation.

Concrete*

REFERRING to training and instruction in concrete technique, Mr. Victor S. Wigmore stated that there should be an institute or college devoted entirely to concrete, where graded courses of instruction could be given to all those dealing with concrete, from the operatives upwards, containing workshops in which they could see and handle the various types of equipment and materials, and see instructional films. It should be possible for clerks of works, resident engineers, &c., to attend occasionally for short refresher courses and to become acquainted with new developments here and abroad. The courses must be practical. As regards the cost, Mr. Wigmore said that some might argue that the scheme should be sponsored by the Government, but he thought he would be interpreting the feelings of the concrete industry if he said they were fully capable of taking the initiative themselves once they were convinced of the necessity.

He then criticised concrete specifications and said the present out-of-date method acted as a deterrent to good quality and penalised the conscientious contractor. It was also wasteful of cement. As every ton of cement required roughly 8 cwt. of coal for burning and operational work, we, as a nation, could not afford to waste cement. The remedy was to amend specifications so that full advantage could be made of modern methods of mechanical compaction to use concrete with a lower water-cement ratio. Instead of giving the mix proportions, the specification would state the maximum water to cement ratio, the maximum slump (or other consistency factor) and the minimum test requirements. The contractor would then decide the proportions and submit them to the controlling authority, together with the neces-

* Extracted from Presidential Address, the Society of Engineers. February 3rd.

sary test data. The greatest obstacle to be overcome was the type of mind which, chiefly through lack of knowledge of concrete, was afraid either to try anything until everyone else was doing it or because it had not been done by his father before him. He hoped that the matter would be carefully considered by those in authority. Some contract specifications were too voluminous and attempted to teach the contractor his job and to tie him down on every detail.

A more accurate field test for workability than the slump test was long overdue. He described a simple field apparatus which he had devised and which he referred to as a "Consistometer." The apparatus combined penetration and vibration, the vibration being obtained by turning a handle. The test procedure was to fill the container with concrete, turn the handle and then read the "consistency factor" directly from a revolution counter. His tests were not yet complete, but soon he hoped to be able to give minimum and maximum "consistency factors" for the different types of work. So far the "consistency factors" ranged from about 50 for a 6in slump up to about 500 for a stiff mix with no slump.

Mr. Wigmore referred to the greater interest now being taken in aggregate grading curves, but said that care must be taken not to clamp down too tightly on grading limits and ignore practical conditions. Grading was important, but a pint or two extra of water could counteract the benefits of proper grading. There was no combined grading curve which was ideal for all conditions. He listed the various points which must be taken into consideration when designing concrete. The secret of grading curves was to produce a mixture with the lowest water to cement ratio which could be brought to a quivering, quaky condition by the method of placing employed. He wished to dispel the idea that vibration in itself increased the strength of concrete. Its function was to enable concrete to be placed that was too stiff for hand compaction. It was the reduced water to cement ratio that gave the increased strength, not the vibration.

Canadian Engineering Notes

Large Cement Plant

Said to be the biggest of its kind assembled in Canada, the concrete plant designed and used for construction work on the Shipshaw power development has been sold by War Assets Corporation to the Hydro-Electric Power Commission of Ontario. The plant consisted of four units, each capable of individual employment, of which the first is now being shipped to Chalk River, Ontario, for the new power development construction job at that site. The plant is an assembly of four 2 cubic yard mixers, capable of providing 4000 cubic yards or 8000 tons of concrete for a 20-hour day.

Steel

A survey of Canada's steel industry for 1946 shows that much essential production was lost as a consequence of labour-management disputes. Had it not been for a prolonged strike against the three major steel producers, practically all the steel capacity added during the war would have been fully occupied throughout the year. Total production of ingots and castings for the year is estimated at 2,250,000 tons, some 630,000 tons below the output of 1945 and 850,000 tons below 1942, which was the war year of maximum output. Notwithstanding the loss of production, total output for 1946 was still approximately 50 per cent above the output of 1939. In addition to the effects of the steel strike, which lasted from July 14th to October 4th, the coal strike in the United States earlier in the year also adversely affected Canadian steel output. It is estimated that as a result of the strike, production of finished steel was reduced by approximately 300,000 tons. Since the industry was operating practically at capacity when the strike was called, this loss of production cannot be recovered. In addition to the inconvenience suffered by the public and the loss to industry, it is estimated that, in the case of the striking employees of one company, approximately eight years of full-time work will be required before the loss in wages is recovered through the 3 cents an hour additional increase in wage gained as a result of the strike.

New Smelter Industry

There is to come into being soon in the Lake St. John district of the Province of Quebec, an extensive new smelter industry, which will enable the province to obtain the full benefit of its rich zinc deposits. Setting up of the new smelter will relieve Quebec from its present obligations of importing from the United States the large quantities of sulphur required for the newsprint industry. In making the announcement, Premier Duplessis said the work of construction would be commenced early this year, and the hope was that the smelter would be in operation in 1948. The smelter will cost approximately 11,000,000 dollars, and the project comes about following negotiations with Howard E. Young, president of the American Zinc, Lead and Smelting Company, and H. W. Knight, president of the Golden Manitou Mines, Ltd. The operations will be carried out by the American-Quebec Zinc Refining Company, Ltd., a company incorporated under the laws of Quebec. The plant to come into existence will refine the zinc and concentrates taken from the mines of the province and elsewhere. In completing his announcement, Premier Duplessis said that as the possibilities of sulphur production in conjunction with the establishment of the zinc smelter are very considerable, it might be possible to produce sulphur on a great scale.

Electrical Developments

Electrical production by the central stations during the first ten months of 1946 was 2·6 per cent higher than the average of the same periods in 1943, 1944 and 1945. At the end of the year a total capacity of more than 400,000 h.p. was under construction, and preliminary work was under way on projects involving an additional 600,000 h.p. Greatest activity is taking place in Ontario. At the end of the year four major projects were under construction:—A 70,000 h.p. power unit at DeCew Falls; 81,000 h.p. at Stewartville, on the Madawaska River; six units of 60,000 h.p. each on the Ottawa River, 138 miles north of Ottawa; and two units of 27,000 h.p. each, near Terrace Bay on Lake Superior. During the year the Ontario Hydro-Electric Power Commission installed 1150 miles of rural distribution lines and 377 miles of high-tension transmission lines. In British Columbia two hydro-electric developments, one at Campbell River on Victoria Island, involving two 25,000 h.p. units, and the other at Bridge River, a 62,000 h.p. unit, are under construction. Several smaller developments are also under way in that province. In the Province of Quebec projects under development include a 50,000 h.p. unit by the Beauharnois Commission; a 24,000 h.p. unit at Farmers Rapids, by the Gatineau Power Company; and a small project in Saguenay County by the Canadian International Paper Company.

New Radar Device

National Research Council technicians have developed a device that will shorten the time for certain phases of map-making from months to days. A product of radar research, it is an altimeter, which is now being constructed for the mines and resources department, parent body of Canada's efforts to map her vast areas. For years mapping from the air has shown only the flat surface of the earth, while ground survey parties went about the slow task of recording the topography for measurement of the heights of the hills and mountains and the depths of the valleys. Now, from the altimeter recordings in an aircraft, the exact profile of any area can, it is claimed, be filled in on charts. It can contour-map 200 square miles in three hours. The altimeter is being fitted to an N.R.C. aircraft at Arnprior, Ontario, and will be initially operated in some contour mapping of the nearby Gatineau hills. With great areas still uncharted and still others charted incorrectly, it will, it is considered, be of very great value.

Expansion and Improvement of Telephone Services

The Bell Telephone Company of Canada recently announced that its 1946 outlay of close to 38 million dollars is the first step in a 100 million dollar plan for expansion and improvement to continue till the end of 1947. Further steps to be taken in the immediate future include the overtaking of service orders deferred by material shortages; restoration to and improvement on pre-war levels of standard telephone performance, conversion of more manual exchanges to modern dial operation, and rehabilitation of plant equipment generally to the point it had reached before all-out war effort and unexampled post-war activity strained it to the limit. Earliest effect of the continuing programme is revealed in a ten-months' net increase of some 109,000 telephones added throughout the provinces of Ontario and Quebec since the beginning of 1946.

Major projects to be undertaken are completion of the new Montreal-Ste. Agathe cable route, much of it underground, and the laying of buried cable between Montreal and Trois Rivieres, to be placed in service in 1947. Carrier equipment which permits twelve simultaneous conversations over one pair of wires is being installed on circuits in the Montreal-Ottawa-Toronto cable. Similar equipment is being added on open-wire lines between Toronto and Winnepeg for service in 1947. More talking channels in the near future will link many branch routes with main lines of the Trans-Canada Telephone System, while the latter are being enlarged from Montreal east to the New Brunswick border to provide more talk-tracks to the Maritimes, and from Oshawa, Ontario, westward to Winnipeg. On this route a new high-frequency, twelve-channel, carrier system will be the first of its kind in Canada. Long distance facilities thus augmented between Ontario, Quebec and Manitoba will connect with open-wire at Winnipeg and a three-channel carrier system running to the west coast.

New Pig Iron Plant

The first major step towards establishing a West Coast steel industry has been taken by the British Columbia Tube Works, Ltd., a new company which has acquired a big site in Burnaby, B.C. The plant formerly was the Ardley sub-station built by Canadian Western Electric Company. An electric steel furnace with a capacity of 6 tons per hour has been installed, along with a 15-ton overhead electric crane with a 35ft span. This furnace is now in continuous operation seven days a week, converting steel scrap into foundry pig iron. At present, all pig iron for Vancouver foundries is shipped from Eastern Canada and the United States. Cast iron soil pipes will be cast direct from the furnace by a centrifugal casting machine at the rate of 20 pipes per hour. A second casting machine is on order and is expected to double production in the near future. The present moulds for the test heats are sand, but a modern casting machine on a conveyor system with a capacity of five to seven tons of pig iron per hour will be installed shortly.

Tailless Aircraft

Canada's National Research Council has developed a model tailless aircraft, 47ft in wing span and weighing approximately 4000 pounds, it is announced in the annual report of the council. Describing development of the craft as "one of the most interesting projects undertaken in recent years," the President, Mr. C. J. Mackenzie, said that successful trials have been reported in recent months.

Industrial and Labour Notes

Finance for Industry

Speaking to the Association of International Accountants in London on Wednesday of last week, Lord Piercy, chairman of the Industrial and Commercial Finance Corporation, stated that the Corporation had now entered into contracts for advancing over £7,000,000 for the assistance of British industry. He added that the amounts paid out by the Corporation were rather less, because in present circumstances new funds tended to be used rather more slowly than had been expected.

With regard to the outlook for industrial financing, Lord Piercy inclined to the belief that the requisite facilities were on the whole available, and, when added to the existing reserves of industrial concerns, were probably adequate for current needs of development and refinancing. All facilities, whatever they were, must be granted on a basis of very careful selection on account of the heavy incidence of losses if losses were made. Lord Piercy thought, however, that there was at present adequate access to capital for concerns which could justify their claims for obtaining it.

Shipbuilding Hours

The Minister of Labour announced on Tuesday last that the court of inquiry into the difference between the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions on the trade union claim for a forty-four hour week of five days has presented its report.

The report says that it is accepted by the parties to the inquiry that engineering and shipbuilding are sister industries, and with this view the Court is generally in accord. The craftsmen employed in each case are mainly organised in the same craft unions, and it is not just a coincidence that, until the recently negotiated agreement applied a five-day week in the engineering industry, the hours of work in both engineering and shipbuilding had remained the same for many years, and that the reduction in hours in 1919 from fifty-three to forty-seven was made to apply equally to both engineering and shipbuilding. The attention of the Court was drawn to the fact that the engineering and other large industries are now working a five-day week, and also to the fact that a five-day week has been introduced by the Admiralty for workers employed in H.M. dockyards.

The Court concludes, in the light of all the circumstances, that the retention of a week of forty-seven hours in shipbuilding, as oppposed to a week of forty-four hours in general engineering, would lead to difficulties which would render it virtually unworkable. Although the employers expressed the view that any reduction in the working hours was unjustified, it became apparent during the inquiry that the substantial difference between the parties was not whether the hours should be reduced from forty-seven to forty-four, but whether they should fall within a normal working week of five and a half days as opposed to a five-day week. The shipbuilding industry, the report points out, falls naturally into two sections, namely, new work and repair work, and in most districts the two sections are catered for in the same yard, although in one district at least, the Bristol Channel, only repair work is undertaken. Many of those employed in the industry work inside the vessel upon which they are engaged, and as they constantly need artificial light are unaffected by outside conditions, whether of darkness or daylight. A not inconsiderable number of workers, however, is employed outside the vessel, and for this class the tempo of a shipyard quickens as daylight increases, and slows down with the coming of dusk.

If effect was given to the union's proposal to work a forty-four-hour week of five days, it would be necessary to increase the hours at present worked from Monday to Friday by 18 min. a day, and the Court says that it is by no means certain that in the winter months these 18 min. could be economically utilised. The view is therefore expressed that the working of a forty-four-hour week in five days must inevitably result in some loss of production during the winter months, but that the loss would be less in the spring and summer when the whole of the time worked would fall within the period of daylight.

The Court did not disregard the possibility that the psychological effect of requiring shipyard workers to work five and a half days against a normal week of five days in the engineering industry may result in a falling off in shipyard production, more especially in composite yards employing upon the same premises some workers who are employed under the engineering industry's conditions. The Court feels, however, that just as the engineering industry has accepted the principle that the five-day week should be adjusted where necessary to the particular needs of an establishment, so the shipbuilding industry, involving as it does a higher proportion of outdoor work, should accept the principle that a five-day week should be adjusted to meet the longer hours of darkness in winter. The Court therefore suggests that the position could be met by the introduction of a forty-four-hour week to be worked over five and a half days in November, December, January and February, and five days in the remaining months of the year. In making this suggestion, the Court says that it had regard to the circumstances existing in the shipyards to-day, and feels that if the workers were prepared to work for the full hours of each working day the loss of production envisaged through the introduction of a forty-four-hour week would be still further reduced.

Wage Rates in 1946

A survey of rates of wages paid in 1946 and of the principal changes which occurred during the year has now been published by the Ministry of Labour. The observation is made that the upward movement in the general level of wage rates which had occurred during the war became more marked in the first half of 1946 and that from July onwards the position was virtually stable. In the industries for which statistics are regularly compiled by the Ministry, the changes reported up to the end of July resulted in an aggregate net increase in weekly full-time rates of wages of about £2,250,000. The increase in the last five months of 1946 was nearly £600,000, so that in the whole year the aggregate net increase was nearly £2,850,000 in the weekly rates of wages of approximately 7,850,000 workers.

While there were variations in the amounts of increase granted in different industries, it is estimated that at the end of last year the average level of full-time weekly rates of wages in the industries for which information is available, was rather over 8 per cent higher than at the end of 1945, and about 65 per cent higher than at the beginning of the war. Of this 8 per cent, nearly 7 per cent was granted in the first seven months of 1946. Further, it is estimated that the increase in hourly wage rates during 1946 was about 10 per cent, making an average total increase since September, 1939, of 68 to 69 per cent. It should be noted that these percentage increases in weekly and hourly rates of wages do not take into account the marked increases in average earnings which resulted during the war from the operation of other factors such as fuller employment, overtime working and the extension of systems of payment by results.

Dealing with the principal changes in wages during last year, the Ministry of Labour records that in the iron and steel industry there were fluctuations in rates under the operation of sliding-scale arrangements by which wages are adjusted periodically in accordance with movements in the official cost-of-living index figure, and that there was also an increase in June brought about by a revision in the basis of these arrangements. In the whole year, there were net increases of 1s. 1d. to about 1s. 3½d. a shift for men, according to district. In the engineering and allied industries, the national bonus was increased by 6s. a week in April last for men and by 4s. 6d. in May for women, with consequential increases for younger workers and for women engaged on men's work. In addition to this general increase, there were increases in the basic rates of foundry workers, ranging from 2s. to 3s. 6d. a week for men in different occupations. The bonus in the shipbuilding and ship-repairing industry was increased in April by 6s. a week for men and by varying amounts for women and younger workers.

Wages Policy and Production

The National Union of Manufacturers has recently submitted to the Chancellor of the Exchequer a memorandum setting out various suggestions for improving the country's economic position and for increasing industrial output. Amongst other matters, the memorandum stresses the importance of a settled wages policy, and suggests that the Government should put some ceiling upon the constant demands for wage increases and shortening of hours. The export industries are for the time being, the memorandum emphasises, in a seller's market, with a world hungry for goods, but this state of affairs cannot last very long, and producers will then find themselves in a world market where it is essential that they should be able to quote firm competitive prices. But to-day many British manufacturers find it impossible to quote firm prices, owing to the prevailing uncertainty as to future costs, and the National Union of Manufacturers feels that unless this matter is faced up to now, prices will prove to be no longer competitive when the present phase has passed.

It may be added that the subject of Government policy on wages and production was raised in the House of Commons on the motion for the adjournment on February 5th. Mr. Harold Davies, who introduced the matter, expressed the belief that the trade union movement had the knowledge and sense to work with the Government on a wage policy and wage structure system which would bring the country through the present difficult transition period. Another speaker, Mr. Hollis, wanted to know to what extent it was true that there had been a general decline in productivity per man.

The Parliamentary Secretary to the Ministry of Labour, Mr. Ness Edwards, in winding up the debate, replied first to the point about the general productivity of labour. He said that the situation was so uncertain these days and there were so many things involved to ensure that the production machine ran smoothly and efficiently, that this would be the wrong time, in the Government's view, to try to measure what was the actual productivity either per man-shift or per man-hour. At the appropriate moment, when the situation was easier and freer, Mr. Ness Edwards said that the Government would get some real statistics on the matter, because it was the kernel of the whole situation regarding productivity and the man-power problem. Mr. Ness Edwards went on to make it clear that it was not the policy of the Government to freeze wages. There were, he said, certain industries which must try to bring themselves into the general average of wages paid in this country. Wages, however, were not the only factor; there were welfare conditions and so on, which had to be considered as well, and building materials, equipment and labour to provide amenities to industry were not yet available so freely as the Government would like them to be.

French Engineering News

(From our French Correspondent)

PARIS, February 7th.

At the Peugeot automobile plant present production is 110 vehicles a day, roughly divided into one-third 2-ton lorries, of which 20 per cent are exported, one-third light lorries, of which 50 per cent are exported, and one-third "202" cars, of which 80 to 90 per cent are exported. The plant is now employing 9000 workers, and the company hopes, in 1947, to reach its 1939 production level of 300 vehicles a day. This now depends only upon supplies of raw materials.

* * *

Standardisation of coal-mining equipment is going ahead quickly in France. Three commissions hold regular sessions: the Haulage Commission, the Coal Face Commission and the Pneumatic Tools Commission. The work of the first named has already resulted in a plan for standardising mine rails, with three standard gauges for new installations. The standards established for crane cables are expected to simplify their use in mines, and plans are now being studied regarding track installations, switches and cable pulleys. The work of the Coal Face Commission has mainly been concerned with chutes, gallery arches, props and compressor plant.

* * *

France is faced with a large-scale shortage of agricultural machinery in 1947. Out of 200,000 tractors which, in order to overcome labour shortage, were ordered after the liberation, only 20,000 have been delivered as a result of orders placed with both the United States and French factories. The position can be better appreciated when it is realised that France has only 50,000 agricultural tractors, compared with England's 160,000, whereas England has only one-third of France's area under cultivation. Throughout 1946 France only produced 1240 tractors.

The prospects for 1947 are as follows:—At the moment Renault is the largest producer, with 100 tractors a month. By June the Mans factories expect to be turning out 600. There are actually 200 Renault tractors now ready for use, but they are awaiting tyres before being delivered. The Map-Latin plant is producing thirty tractors a month and expects to construct 4000 for the year. The Vierzon Agricultural Company, which is now making twenty a month, hopes to produce fifty a month by July. Altogether, French production of agricultural tractors in 1947 is expected to amount to 10,000 tractors, which is excellent progress compared with 1946. Imports will probably be about 20,000. If the Monnet plan is fulfilled, in the next four years 18,000 tractors, of 10–15 h.p., 70,000 of 16–22 h.p., 24,000 of 23–30 h.p., and 4750 of 30–60 h.p. will be manufactured in France.

* * *

Industrial circles are beginning to wonder whether the coal shortage will not compromise the provisions of the Monnet plan for 1947. The plan lays down for this year an increase in coal production to bring it to 55,500,000 tons, to be obtained by modernisation methods and improvements in coal-face equipment. The plan also envisages imports double those at present coming into the country, but it is doubtful whether they will be realised. At the moment, America delivers 400,000 tons a month, and Poland 80,000 to 90,000 tons a month. From neither country is an appreciable increase expected. In addition, many Polish miners have elected to return to their own country, and it is still not known whether the 41,000 German prisoners working in French mines will be released or not. Although French coal production was 49,000,000 tons in 1946, compared with only 47,600,000 tons in 1938, imports were only 800,000 tons monthly against 2,000,000 tons pre-war. The hope remains that more Ruhr coal will be allocated. At present only 250,000 tons is received, compared with 600,000 tons a month pre-war. Unless coal supplies can be kept up the Monnet plan cannot be fulfilled and the country's recovery will be jeopardised.

Notes and Memoranda

Air and Water

"FLYING SHOWROOM'S" TOUR.—Early in March the world's first "flying showroom" will take the air, when a specially equipped Bristol "Freighter" leaves England on a tour of Northern Europe with a miniature "Britain Can Make It" Exhibition. Visiting Oslo, Stockholm, Gothenburg, Copenhagen, Amsterdam, Brussels and Paris, the "Freighter" will carry a number of stands displaying light engineering and electrical goods. Each stand, constructed of light but strong material and divided from its neighbour by a Perspex partition, will measure 2ft 4in square, and the maximum weight allowance allotted to each exhibitor will be 1 cwt. Accommodation will be provided for a restricted number of exhibitors' representatives, engineers, and an air hostess in charge of a cocktail bar. The tour has been arranged by Mr. Geoffrey Mellor, general organiser of Airborne Exhibitions, Ltd.

P. & O. COMMODORE ENGINEER. — Mr. T. McKeracher became Commodore Engineer of the P. & O. fleet on the retirement of Mr. C. Mabey on January 29th. He is at present chief engineer of the "Maloja," having served for thirty-seven years with the company. He was born at Greenock in 1889 and joined the P. & O. dock staff in April, 1910, before going to sea in the "Persia" as assistant engineer in July of the same year. Mr. McKeracher served in several ships before going to the "Nile" as fourth engineer in January, 1913, and during the first World War he was in the "Socotra" and "Isis" (renamed "Isonzo") as third engineer, the latter ship being then one of the fastest afloat and used as fleet messenger on that account. After the war he returned to ships on normal P. & O. duties and became second engineer on appointment to the "Rawalpindi." During the recent war he was for the most part in the "Maloja" with the rank of Engineer Commander, R.N.R., first on A.M.C. work in the North Atlantic and then trooping.

THE TRANSFER OF SHIPS.—The Minister of Transport has issued a General Sanction under the Ships and Aircraft (Transfer Restriction) Act authorising the transfer between persons entitled to own British ships in accordance with the provisions of Section 1 of the Merchant Shipping Act, 1894, of any ship not under requisition by or on behalf of His Majesty's Government to which the Act applies, or any share in any such ship, the mortgage of any such ship or share therein and the transfer of any mortgage of any such ship or share. The conditions under which these transactions are authorised are that the ship is registered in accordance with the provisions of the Merchant Shipping Act, 1894, at any port of registry in the United Kingdom, Channel Islands or Isle of Man or is entered in the Fishing Boat Register or is both so registered and so entered and does not exceed 50 tons gross tonnage. It should be noted that if a ship, though not exceeding 50 tons gross, is still on requisition to the Government, then it is not covered by the General Sanction and individual application must still be made on a form which can be obtained from any Registrar of Shipping. It should further be noted that the General Sanction does not carry with it any general approval by the Minister to treat a purchase as tonnage replacement expenditure for purposes of the Government Tonnage Replacement Scheme. This General Sanction supersedes the General Sanction of April 17, 1946, which is accordingly revoked.

Miscellanea

TOWN PLANNING DEGREE COURSE.—The University of Durham has established at King's College, Newcastle-upon-Tyne, a department of town and country planning, and has instituted a degree course, which is spread over five years. Professor J. S. Allen is head of the new department, and Mr. Brian Hackett, A.R.I.B.A., has recently been appointed as a full-time specialist lecturer.

A FILTRATION EXHIBITION.—An exhibition of air, oil and fuel filters as used on aircraft and in various branches of industry, which has been organised by Vokes, Ltd., of Guildford, is to be held in the showrooms of the Bristol Aeroplane Company, Ltd., at 69–70, Piccadilly, London, W.1, from February 17th to 28th. This exhibition will be open to the public from 2.30 p.m. till 6 p.m. on the first day and each day from 9 a.m. to 1 p.m. and 2 p.m. to 6 p.m. until February 28th (Sunday excluded).

DANGEROUS OCCURRENCES (NOTIFICATION) REGULATIONS.—The Minister of Labour announces that he has made, under Section 65 of the Factories Act, 1937, the Dangerous Occurrences (Notification) Regulations, 1947. These regulations revoke the Dangerous Occurrences (Notification) Order, 1935, and will come into force on February 1st. They require that notification be given of various classes of occurrences, outlined in the schedule, which take place in factories as defined in the Factories Act, 1937, or in premises or places or in the carrying on of processes to which Part V of that Act applies. Copies of the regulations may be obtained from H.M. Stationery Office, price one penny.

THE EXAMINATION OF COLLIERY ROPES.—As an aid to colliery ropemen who are directly responsible for the examination of winding ropes, the Safety in Mines Research Board published in 1937 a handbook outlining the types and methods of rope examination and the items which should receive attention when making a detailed examination; the forms of deterioration likely to be encountered, and the degree of deterioration permissible before withdrawal of the rope from service. The Board has now reprinted this booklet, which is entitled "The Examination of Colliery Ropes in Service." Copies can be purchased through H.M. Stationery Office, York House, Kingsway, London, W.C.2.

TRADE UNIONS AND THE R.A.F.—The Air Ministry announces that by agreement with the Amalgamated Engineering Union, certain "hostilities only" ex-airmen will, in future, be regarded as fully skilled metal-working craftsmen, and not as dilutees, if employed under the Air Ministry in the appropriate civilian skilled engineering grades. This applies to men who have received wartime training and have completed five years' service as tradesmen. The Air Ministry civilian grades covered by the agreement are armourer, coppersmith, sheet metal worker, fitter (aero-engine, airframe, electrical and motor transport), instrument maker, grinder, miller and turner. A separate agreement has been reached governing trade union recognition of certain ex-R.A.F. tradesmen employed in civil industry.

FILMS IN INDUSTRY.—The Scientific Film Association has arranged a one-day conference on Films in Industry to promote a pooling of ideas and experience between film producers and users. It will be held on Thursday, March 6th, at Caxton Hall, Westminster, S.W.1, and the morning session at 10.30 a.m. will be devoted to lectures and discussions on film production and the use of films and other visual aids in the class-room. The lectures will be illustrated by films and film strips. The afternoon session at 2 p.m., will consist of discussions led by industrial education officers on the use of films as a part of training schemes. The final session at 4.15 p.m. will be an open forum at which a Brains Trust will answer questions. Tickets, price £1 each, inclusive of buffet lunch and tea, may be obtained on application to the conference secretary, Scientific Film Association, 34, Soho Square, London, W.1.

REGULAR EMPLOYMENT FOR MERCHANT NAVY.—The National Maritime Board has now agreed that a Merchant Navy Established Service Scheme shall come into force on Monday, March 31st. The object of the scheme is to enable as many seafarers as possible, after a qualifying period of sea service, to look to the Merchant Navy to offer them a stable and attractive career and greater regularity of employment, and to give shipowners efficient and reliable personnel to man and maintain their ships at sea and in port. In essence the scheme is to provide a two-year contract, renewable for further periods of two years, for shipmasters, officers and ratings who are willing to undertake, on their side, to serve for two years either in the industry generally or with a specific company. When off articles and not working in a ship, an established employee under the scheme will be required to hold himself available for appointment to a ship, and will, unless he is under contract with a particular shipping company, be paid a benefit to be known as "established benefit" which will normally be a supplement to unemployment insurance benefit. Provision is also made for payments during approved courses of training and for sickness benefit over and above the national insurance rates. Those under company contract will receive not less favourable terms than those under the general scheme. The agreement reached on the National Maritime Board has enabled the Government to continue the financing of the present Merchant Navy Reserve Pool until the end of March.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, Feb. 18th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "The Electrical Equipment of a Modern Hospital," J. Tomlinson. 6.15 p.m.

Bradford Engineering Society

Monday, Feb. 17th. — Technical College, Bradford. "Electrical Driving for Textile Machinery," A. J. Francis. 7.15 p.m.

Chemical Engineering Group

To-day, Feb. 14th.—Geological Society, Burlington House, Piccadilly, W.1. "Polyvinyl Chloride and its Co-Polymers," G. Eyssen. 5.30 p.m.

Chemical Society

Wednesday, Feb. 19th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2. "A Century of Chemistry," Sir Harold Hartley. 5 p.m. (Joint meeting.)

Thursday, Feb. 20th.—Burlington House, Piccadilly, W.1. "The Reduction of Oxides by Hydrogen and Carbon Monoxide," W. E. Garner; "The Photo-Chemical Polymerisation of Vinyl Acetate Vapour," H. W. Melville and R. F. Tuckett; "Radical Sensitised Polymerisation of Vinyl Acetate Vapour," H. W. Melville. 7.30 p.m.

Derby Society of Engineers

Monday, Feb. 24th.—School of Arts, Green Lane, Derby. "Malleable Cast Iron—a Material for the Engineer," W. C. Marshall. 7 p.m.

Illuminating Engineering Society

Friday, Feb. 28th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. Presidential Address, J. S. Dow. 6 p.m.

Institute of Economic Engineering

To-day, Feb. 14th.—Cowdray Hall, Henrietta Place, W.1. "Methods of Wage Calculation," C. V. Berridge. 7 p.m.

Institute of Marine Engineers

Thursday, Feb. 20th.—85, The Minories, E.C.3. Films, "Kelvin—Master of Measurement" and "Romance of Engineering." 7 p.m.

Friday, Feb. 21st.—S. WALES BRANCH: Technical College, Swansea. "Gas Turbine Design and Operation," A. T. Bowden. 7 p.m.

Thursday, Feb. 27th.—JUNIOR SECTION: East Ham Technical College, Barking Road, E.6. "The Production of Oil Fuel," J. S. Jackson. 7 p.m.

Institute of Physics

Tuesday, Feb. 18th.—SCOTTISH BRANCH: The University, Glasgow. "Dielectric Heating," A. J. Maddock.

Friday, Feb. 28th.—E.L.M.A., 2, Savoy Hill, W.C.2. "Continental Wartime Developments in Spectroscopic Technique," E. van Someren. 6.30 p.m.

Institution of British Agricultural Engineers

Tuesday, Feb. 18th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Milking Machines," H. P. Hall. 2 p.m.

Institution of Civil Engineers

Tuesday, Feb. 18th.—Great George Street, S.W.1. "The Civil Engineer as Arbitrator," E. J. Rimmer. 5.30 p.m.

Tuesday, Feb. 25th.—S. WALES ASSOC.: Institute of Engineers, Park Place, Cardiff. "Codes of Practice," C. Roland Woods. 6 p.m.

Thursday, Feb. 27th.—BIRMINGHAM ASSOC.: Loughborough College, Loughborough. "The Application of Welding to Bridge Construction," R. G. Braithwaite.

Friday, Feb. 28th.—YORKSHIRE ASSOC.: Royal Victoria Station Hotel, Sheffield. "Methods of Determining Mechanical and Manual Costs on Civil Engineering Work," J. A. Neylon. 7 p.m.

Institution of Electrical Engineers

Saturday, Feb. 15th.—N. MIDLAND STUDENTS: Corporation Electricity Department, Whitehall Road, Leeds. "The Place of the Gas Turbine in Future Electricity Generation," B. V. Poulston. 2.30 p.m.

Wednesday, Feb. 19th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "The Design of High-Fidelity Disc-Recording Equipment," H. Davies. 5.30 p.m.—N. EASTERN CENTRE: Literary and Philosophical Society, Newcastle on-Tyne. "The Generation and Wholesale Distribution of Electricity," J. Hacking. 7 p.m.

Monday, Feb. 24th.—N. EASTERN CENTRE: Neville Hall, Newcastle-on-Tyne. "Modern H.V. Wood Pole Lines: Their Operational Characteristics," G. T. Garwood. 6.15 p.m.

Tuesday, Feb. 25th.—SCOTTISH CENTRE: Royal Technical College, George Street, Glasgow. "Direct-Current Arc Welding Generators and Systems," J. C., J. W. and W. L. Macfarlane. 6.15 p.m.

Thursday, Feb. 27th.—Grand Hall, Connaught Rooms, Great Queen Street, W.C.2. Annual dinner and reunion. 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Feb. 18th.—39, Elmbank Crescent, Glasgow. "Some Notes on Propeller Theory," L. C. Burrill. 6.30 p.m.

Institution of Heating and Ventilating Engineers

Monday, Feb. 17th.—N.E. COAST BRANCH: Inst. of Mining and Mechanical Engineers, Neville Hall, Newcastle-on-Tyne. "Fans and their Applications," Mr. Donaldson. 6.30 p.m.

Tuesday, Feb. 25th.—SCOTTISH BRANCH: Inst. of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. "Modern Electric Panel Heating," A. C. F. Mackadam. 7.30 p.m.

Wednesday, Feb. 26th.—LIVERPOOL BRANCH: Accountants' Hall, Fenwick Street, Liverpool. "Steam Raising and Hot Water Supply by Electrode Boilers," E. Covington. 6.30 p.m.

Institution of Locomotive Engineers

Wednesday, Feb. 19th.—Inst. of Mechanical Engineers, Storey's Gate, S.W.1. "Welded Carriage Underframes on the L.M.S. Railway," A. N. Moon. 5.30 p.m.

Institution of Mechanical Engineers

Monday, Feb. 17th.—GRADUATES' SECTION: Storey's Gate, S.W.1. "The Art and Mechanism of Weaving," Ian S. Porter. 6.30 p.m.—MIDLAND GRADUATES: James Watt Memorial Institute, Great Charles Street, Birmingham. "Resistance Welding," F. W. Rowlands. 7 p.m.

Tuesday, Feb. 18th.—Storey's Gate, St. James's Park, S.W.1. "The Flow of Metals," Dr. A. Nadai. 3 p.m. and 5.30 p.m.

Thursday, Feb. 20th.—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham. "The Application of Electronics to Heavy Engineering," W. Wilson. 5.30 p.m. —MANCHESTER BRANCH: College of Technology, Sackville Street, Manchester. "The Flow of Metals," A. Nadai. 2.30 p.m. and 5.30 p.m.

Friday, Feb. 21st.—Storey's Gate, St. James's Park, S.W.1. "The Development of Locomotive Power at Speed," E. L. Diamond. 5.30 p.m.

Saturday, Feb. 22nd. — N.-EASTERN GRADUATES: Hartlepool Gas and Water Company, Victoria Road, West Hartlepool. "Modern Steam Generating Plant," J. R. Frank. 2.30 p.m.

Thursday, Feb. 27th.—SOUTHERN BRANCH: Royal Aircraft Establishment, Farnborough. "The Development of Gas Turbine Power Plants for Traction Purposes in Germany," Lieut. Colonel R. H. Bright. 6.45 p.m.

Institution of Mining and Metallurgy

Thursday, Feb. 20th.—Geological Society, Burlington House, Piccadilly, W.1. "An Experimental and Theoretical Investigation of Bias Error in Mine Sampling, with Special Reference to Narrow Gold Reefs," H. S. Sichel. 5 p.m.

Institution of Post Office Electrical Engineers

Monday, Feb. 24th.—Faraday Building (South Block), Knightrider Street, E.C.4. "Automatic Routine Testing," W. J. Marshall. 5 p.m.

Institution of Production Engineers

Saturday, Feb. 15th.—YORKSHIRE GRADUATES: Great Northern Hotel, Bradford. "Cost Control as an Aid to Management," R. Cooper. 2.30 p.m.

Monday, Feb. 17th.—DERBY SUB-SECTION: School of Arts, Green Lane, Derby. "Motion Study," Miss Shaw. 6.45 p.m.—HALIFAX SECTION: Whiteley's Cafe, Westgate, Huddersfield. "The Manufacture of Seamless Steel Tubes," J. W. Jenkin. 7 p.m.

Wednesday, Feb. 19th.—N.E. SECTION: Neville Hall Mining Institution, Newcastle-on-Tyne. "Apprentice Training," W. A. Hildrow and G. M. Baker. 6.30 p.m.—PRESTON SECTION: Clayton, Goodfellow and Co., Ltd., Blackburn. "Modern Heat-Treatment," A. G. McDonald. 7.15 p.m.—SHEFFIELD SECTION: Royal Victoria Hotel, Sheffield. "Furnaceless Heating by Town's Gas," J. F. Wright and J. Palser. 6.30 p.m.—BIRMINGHAM SECTION: James Watt Institute, Great Charles Street, Birmingham. "Apprentice Training," Lieut. R. T. M. Toyn. 7 p.m.

Thursday, Feb. 20th.—GLASGOW SECTION: Inst. of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. "The Application of Production Standards in Industry," H. G. Houghton. 7.30 p.m.—LEICESTER SECTION: College of Technology, Leicester. "Fabrication Design as a Substitute for Castings," F. G. Rout. 7 p.m. (Joint meeting.)

Friday, Feb. 21st.—WESTERN SECTION: Grand Hotel, Broad Street, Bristol. "High-Frequency Induction Heating," S. Cosgrove. 6.45 p.m.

Wednesday, Feb. 26th.—MANCHESTER SECTION: College of Technology, Manchester. "Function and Operations of Work Committees in the Engineering Industry," W. Symes. 7.15 p.m.

Friday, Feb. 28th.—HALIFAX GRADUATES: Technical College, Huddersfield. "Powder Metallurgy." 7 p.m.—E. COUNTIES SECTION: Electric House, Ipswich. Discussion, "Relationship between Research and Production Engineering." 7.15 p.m.

Institution of Structural Engineers

Thursday, Feb. 27th.—11, Upper Belgrave Street, S.W.1. "Structural Welding During the War and After," A. Ramsay Moon. 6 p.m.

Institution of Water Engineers

Wednesday, Feb. 26th.—S.-EASTERN SECTION: Inst. of Civil Engineers, Great George Street, S.W.1. "Notes on the Selection of Pumping Plant," J. M. Linton Bogle. 2.30 p.m.

Junior Institution of Engineers

To-day, Feb. 14th.—39, Victoria Street, S.W.1. Chairman's Address, "Windmills," Rex Wailes. 6.30 p.m.

Friday, Feb. 21st.—39, Victoria Street, S.W.1. "Light and Colour," L. H. A. Carr. 6.30 p.m.

Monday, Feb. 24th.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. Chairman's address, J. Rotherham. 7.15 p.m.

Friday, Feb. 28th.—39, Victoria Street, S.W.1. "The Evolution of the Automobile Gearbox," W. J. Kease. 6.30 p.m.

Keighley Association of Engineers

To-day, Feb. 14th.—Devonshire Buildings, Devonshire Street, Keighley. "Refrigeration," J. Orpin. 7.30 p.m.

Manchester Association of Engineers

Friday, Feb. 21st.—Engineers' Club, 17, Albert Square, Manchester. "Oilfield Drilling and Production Practice in Great Britain," R. K. Dickie. 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Feb. 28th.—Mining Institute, Newcastle-on-Tyne. "Various Refrigerating Gases and their Suitabilities for Marine Purposes," J. D. Farmer. 6 p.m.

N.W. Fuel Luncheon Club

Wednesday, Feb. 19th.—Engineer's Club, Albert Square, Manchester. Films, "Steam Utilisation" and "Furnace Practice." 12.30 p.m.

Royal Institution of Chartered Surveyors

Monday, Feb. 17th.—12, Great George Street, S.W.1. "Provisions of the Town and Country Planning Bill," Right Hon. Lewis Silkin, M.P. 5.30 p.m.

Royal Institution of Great Britain

To-day, Feb. 14th.—21, Albemarle Street, W.1. "Natural Science and the Fine Arts," F. I. G. Rawlins. 9 p.m.

Friday, Feb. 21st.—21, Albemarle Street, W.1. "Problems and Techniques of Modern Nuclear Physics," M. L. Oliphant. 9 p.m.

Royal Society of Arts

Wednesday, Feb. 19th.—John Adam Street, Adelphi, W.C.2. "Modern Astronomical Instruments," Sir H. Spencer Jones. 5 p.m.

Royal Statistical Society

Wednesday, Feb. 19th.—BIRMINGHAM SECTION (INDUSTRIAL APPLICATIONS SECTION): Chamber of Commerce, 95, New Street, Birmingham. "Correlation and Regression," B. Martin. 6.30 p.m.

Monday, Feb. 24th.—SHEFFIELD GROUP (INDUSTRIAL APPLICATIONS SECTION): Department of Mechanical Engineering, the University, St. George's Square, Sheffield. "Statistical Study of Twenty-Eight Factors Affecting Coke Consumption in a Blast-Furnace," G. Harcourt Jowett. 6.30 p.m.

Sheffield Metallurgical Association

Tuesday, Feb. 25th.—198, West Street, Sheffield. "Photo-Elasticity Applied to Design Problems," R. B. Heywood. 6.30 p.m.

Sheffield Society of Engineers and Metallurgists

Monday, Feb. 17th.—Royal Victoria Station Hotel, Sheffield. "Metallurgical Aspects of Compressed Gas Cylinders," N. P. Allen. 6.15 p.m.

Personal and Business

MR. H. A. WAINWRIGHT has been elected a director of Birmetals, Ltd., and Birmabright, Ltd.

MR. REX BATE has been appointed general sales manager of the Brush Electrical Engineering Company, Ltd.

MR. R. ARBUTHNOTT has been appointed joint managing director of the North British Locomotive Company, Ltd.

RICHARD KLINGER, Ltd., has opened a branch office and depot at 11, Goree Piazzas, Liverpool, 3 (telephone, Central 3497).

TANGYES, Ltd., announces that its London office has been transferred to 60, Grosvenor Street, W.1 (telephone, Mayfair 1338).

MR. R. W. P. HOLT, M.I. Mech. E., has been appointed a director of the Widnes Foundry and Engineering Company, Ltd.

THE FAIREY AVIATION COMPANY, Ltd., 24, Bruton Street, London, W.1, announces that its telephone number is now Mayfair 8791.

MR. A. MCVIE has been appointed commercial director of Standard Telephones and Cables, Ltd., in succession to Mr. C. W. Eve, who is retiring.

MR. HAROLD WILMOT, managing director of Beyer, Peacock and Co., Ltd., has been elected President of the Locomotive Manufacturers' Association.

GEORGE COHEN, SONS AND CO., Ltd., has been appointed sole agent for the Coborn-Wadley combination punching, shearing, cropping and notching machine.

THE BOARD OF TRADE REGIONAL OFFICE (WALES) is moving on February 17th to Imperial Buildings, Mount Stuart Square, Docks, Cardiff (telephone, Cardiff 5920).

THE GEAR GRINDING COMPANY, Ltd., announces that, by mutual arrangement, A. C. Wickman, Ltd., has ceased to be sole agent for its gear-grinding machines and other products.

CROMPTON PARKINSON, Ltd., announces that Mr. H. H. Spencer, M.I.E.E., has relinquished his position as branch manager of the London plant division to take up special duties in the sales director's department. Mr. J. B. Scott has become branch manager of the London plant division, and Mr. R. Speirs, M.I.E.E., branch manager of the Manchester plant division. Mr. T. A. Littlewood has been appointed manager of the Birmingham plant division.

A Seven-Day Journal

New Generating Stations

It is announced that the Central Electricity Board has adopted, without modification, the "North-West England and North Wales (Alteration and Extension) Scheme, 1947." This scheme, which was referred to in our issue of December 20th, 1946, provides for the erection, when they have been authorised, of four new selected generating stations, each with an initial installation of 130,000 kW of generating plant. One of these stations is required to be completed in time to meet the estimated demand arising in East Lancashire in 1950. The remaining three stations will be needed to meet the anticipated growth in demand in other parts of the scheme area in later years. It will be recalled that there are at present twenty-nine selected stations operating in the area under the existing schemes, which also make provision for the construction of three further new stations, apart from the four stations envisaged in the new alterations and extensions scheme outlined above.

Coal and the Electricity Industry

In the course of a speech delivered at the luncheon of the Radio Industries Club, held at the Connaught Rooms on Tuesday, February 25th, Sir Robert Renwick, the chairman of the County of London Electricity Supply Company, said that the principal cause of the fuel crisis was lack of coal. Home consumption of coal, he contended, had not increased and was the same as in 1939. It was true that the coal consumed by power stations had increased; but, he said, that was all to the good, for it was the most economical way of burning coal. Speaking of the Government's allocation scheme for coal for power stations, Sir Robert gave figures for the South-Eastern Area. The amount of coal allocated against the estimate requirements from October 25, 1946, to February 5th this year was 2,022,000 tons, but the amount delivered was only 1,731,000 tons, leaving a deficit of 291,000 tons. On February 7th the stocks of coal in the area only amounted to 181,760 tons. If the total coal allocated to the area in the period had only been delivered, the stocks in the area on that date would have been nearly 473,000 tons, which would have equalled three and a half weeks' supply at the normal rate of consumption. Coal, Sir Robert went on to say, was the key. If we were to achieve the full target of export of manufactured goods the minimum coal production target for 1947 should, he said, be 220,000,000 tons, of which at least 10,000,000 tons must go to re-create stocks. He disagreed with the Government's 200,000,000 tons target figure given in the White Paper. Deficiencies in plant would rise, he thought, to 1,700,000 kW in the next two years. The only possible solution was, he said, to give manufacturers of plant and those engaged on the construction of power stations a sufficiently high priority to hasten the production of power plant for our own stations at the expense temporarily of plant for export.

The Institution of Electrical Engineers

The first annual dinner of the Institution of Electrical Engineers to be held since the sequence of these functions was interrupted by the outbreak of war took place at the Connaught Rooms, W.C.1, on Thursday, February 27th. Proposing the toast of the Institution, Sir Stafford Cripps dwelt at some length on this country's reconstruction problems, aggravated as they were by the prevailing shortage of generating plant and of coal. Sir Stafford emphasised the urgent necessity for economy, and suggested that all the skill and ingenuity that electrical engineers could command would be needed for the vital task of ensuring that electricity was used to the best advantage for increasing industrial production. Small generating sets must be installed wherever possible until the existing deficiency of plant could be made good. In the meantime most of the attractive electrical appliances manufactured by British engineers must be reserved for export. Responding to the toast, the President, Mr. V. Z. de Ferranti, welcomed the proposal to stagger working hours in industry. With the available plant a substantial increase in the number of units generated could be obtained by spreading the demand as evenly as possible throughout a twenty-four hour day. Although the need for economy was evident, Mr. Ferranti deplored the suggestion that drastic restrictions in the consumption of electricity could not be avoided. On the contrary, he maintained that there was no better way of using the energy of coal than in the generation of electricity for providing heat and power conveniently and efficiently. The present austerity could not shake his faith in the "all-electric idea," which was still the electrical engineer's target.

The Flow of Metals under Various Stress Conditions

At a special meeting of the Institution of Mechanical Engineers on Tuesday, February 18th, the James Clayton Lecture was delivered by Dr. Ing. A. L. Nadai, whose subject was "The Flow of Metals under Various Stress Conditions." In the course of the lecture, Dr. Nadai pointed out that while the theory of elasticity was mostly concerned with very small strains, a theoretical treatment of the permanent or plastic deformations of metals must also frequently take account of strains of an order of ten to a hundred times larger than the strains that can be sustained elastically. Engineering means for dealing with finite strains of this order were reviewed, and also certain new types of strains that appeared to offer possibilities for expressing the stress-strain relations required for developing the theories of the flow of metals under various conditions. Dr. Nadai, it may be stated, studied at the Federal Polytechnical Institute, Zürich, and was at one time assistant to Dr. Eugen Meyer, Technical University of Berlin, where he received the degree of Doctor of Engineering for a thesis on thermo-elastic effects in steel. He has also conducted extensive experimental investigations on the conditions of yielding of metals. In 1927 Dr. Nadai became consulting engineer in the Research Laboratories of the Westinghouse Electric Corporation, and in 1933 he was appointed chairman of the American Society of Mechanical Engineers' Research Committee on Plastic Flow of Metals.

Medal of the Institution of Mining Engineers

The Council of the Institution of Mining Engineers has awarded the medal of the Institution, the highest honour in its power to bestow, to Sir Charles Carlow Reid, Production Member of the National Coal Board, in recognition of his long and distinguished services to the mining industry and the Institution, and of his special contribution to the advancement of the theory and practice of coal mining. Sir Charles Reid, who is sixty-seven years of age, received his early education at Leven Public School, and at the age of fourteen was an apprentice office clerk, and on completing his term of apprenticeship he went down the pit. His marked ability singled him out for early promotion, and he became assistant to the manager at the Aitken Colliery, Fife, and subsequently he was appointed manager at the Donbristle Colliery. When this pit was absorbed in the Fife Coal Company he was appointed agent to a group of the company's pits, and in 1923 he became the general mining manager of the whole of the Fife Coal Company's workings. In 1931 he was appointed a director of the company, and a few years later he became its general manager. In 1942 he was seconded to Government service and was appointed the Regional Production Director of the Ministry of Fuel and Power for Scotland. The following year Sir Charles became Production Director for Great Britain. In 1945 he became Production and Technical Adviser to the Ministry of Fuel and Power, and at the same time he acted as Chairman of the Technical Advisory Committee, which, we may recall, issued the Reid Report in March, 1945. When the National Coal Board was formed in July, 1946, Sir Charles Reid was appointed Production Member of the Board.

Launch of Cunard White Star Liner "Parthia"

On Tuesday, February 25th, from the No. 3 slipway at the Queen's Island yard of Harland and Wolff, Ltd., Belfast, Northern Ireland's first passenger liner of the year was launched. She is the "Parthia," for the Cunard White Star Line. The "Parthia" is the third vessel to be launched in the Cunard White Star Company's post-war programme. With an overall length of 540ft, a beam of 70ft, and a gross tonnage of 14,000, she is designed to carry in her six holds 7000 tons of cargo, which will include some 680 tons of refrigerated freight. Passenger accommodation for 250 persons is provided for, chiefly on A and B decks. The propelling machinery comprises a twin screw arrangement of single reduction-geared turbines, taking steam from two Foster Wheeler oil-fired water-tube boilers, with a working pressure of 430 lb per square inch, and a final steam temperature of 750 deg. Fah. The main turbines have a total designed output of 13,600 s.h.p., corresponding to a service speed of 17 knots. For the auxiliary power and lighting there are four oil engine driven generating sets, while low pressure steam for heating and domestic use at 100 lb per square inch will be furnished by two Cochran vertical type boilers. It is expected that the "Parthia" will be ready for service late in the year.

The Late Mr. H. E. Chasteney, Chief Inspector of Factories

It is with the deepest regret that we have to record the death on Tuesday, February 18th, in St. Mary's Hospital, Paddington, following a street accident, of Mr. Howard Everson Chasteney, his Majesty's Chief Inspector of Factories. Mr. Chasteney was returning home from a meeting convened by The British Council on Monday evening, February 17th, when he was knocked down by a motor vehicle in the Bayswater Road, and sustained fatal injuries. He was 59 years of age and was born at Nottingham. He received his education at Nottingham High School and at St. John's College, Cambridge, where he had a distinguished academic career and took a First in Part I, and was a Wrangler in Part II of the Mathematical Tripos, and gained a Second in Part I of the Natural Science Tripos. He was, too, a distinguished oarsman. In 1913 he entered the Civil Service as a factory inspector, and was posted to Sheffield. During the 1914–1918 war he served in the Royal Engineers and was wounded. He returned to Sheffield and was later appointed to take charge of the Liverpool area, including Birkenhead and West Cheshire. From Liverpool he moved to London, where he was given charge of the North London and Woolwich Districts. In 1937 he was appointed Deputy Superintending Inspector in Manchester. The following year he returned to London as Deputy Chief Inspector. During the recent war, he had much to do with Civil Defence problems in factories. On the retirement of Sir Wilfred Garrett, in 1946, Mr. Chasteney was made Chief Inspector of Factories. He will long be remembered as a man with sound judgment who possessed a wide knowledge of industry and who exercised real care for the well-being of factory workers.

Lord Kelvin and the Diesel Engine

(Contributed)

No. I

THE discovery of a copy of the Report on the "Diesel Internal Combustion Motor" made by Lord Kelvin, in 1897, to the Mirrlees Watson and Yaryan Company, Ltd., Glasgow, revives memories of the early days of the diesel engine and provides, incidentally, an interesting side-light on Lord Kelvin's method in analysing the subject matter and claims in Diesel's famous patent. The Report (which is dated March 31, 1897) had long been lost sight of. It was, indeed, thought to have entirely vanished until, quite recently, a typewritten copy came into the hands of Mr. Charles Day, who was so prominently identified with the development of the diesel engine in Great Britain.

Rudolf Diesel has himself recorded that at the time of his negotiations with the Mirrlees Watson and Yaryan Company, he "had the honour of being received several times by Lord Kelvin when in Glasgow and to discuss with him the whole question of the new motor." As is well known, Lord Kelvin was among the most eminent of all exponents of the application of science in industry. "There cannot (he said in a memorable address) be a greater mistake than that of looking superciliously upon practical applications of science. The life and soul of science is its practical application." True to this axiom, he took a very active interest in the internal combustion engine. For example, during 1879–1880 he installed a Clerk two-cycle gas engine at the Physics Laboratory of the University of Glasgow. This engine drove an electric generator, the supply from which was connected to his house adjoining the laboratory. Indeed, Lord Kelvin maintained that his was "the first house on this planet" to be illuminated throughout by electricity. Later (in February, 1888), he made a report on the Priestman petroleum engine, the signed original of which is still extant. In this report, Lord Kelvin remarks, *inter alia*, that "as the (Priestman) engine is governed by reducing the charge admitted into the cylinder instead of cutting off the supply, the explosion takes place with great regularity, thus securing steady running with or without load, and with varied loads, which, judging from my own experience of the irregular running of gas engines, running at anything less than full load, is a very important advantage." He doubtless had in mind his experience with the house lighting installation.

But, apart altogether from Lord Kelvin's actual knowledge of gas and oil engines, there was a further and more significant circumstance which renders his report on the diesel engine of peculiar interest to engineers in general and to students of heat engines in particular: During 1845 (thirteen years before Diesel was born), Lord Kelvin —then Mr. William Thomson—had worked for four months in the laboratory of Regnault at the University of Paris, and while there had seen the paper by Paul Emile Clapeyron in which that physicist dealt graphically with the work of the illustrious N-L. Sadi Carnot. It was, moreover, Lord Kelvin who thereafter introduced the reasonings of Carnot with results which profoundly influenced scientific teaching in the nineteenth century. We also know that he had himself experimented on the heat developed by the compression of air. It must, therefore, have been with very special interest that he examined the proposals of Diesel, who, in formulating his "process," had been much influenced by the ideas of Carnot. Here was a patent in which an attempt had been made to utilise, as far as might be possible, Carnot's reasonings as to the cycle of operations upon which a perfect heat engine must work.

Lord Kelvin's report is, as could be expected in the circumstances, the report of a physicist rather than a patent attorney, just as Diesel's patent is that of a physicist rather than a practical engineer. After going over the description of the proposed method of working, Lord Kelvin remarks that "The conditions, of course, cannot be *perfectly* realised (the interlineation is Lord Kelvin's) in any real machine: but Diesel has shown how to make a good, practical approximation to their fulfilment, whether the fuel be gas, powdered, solid, or oil." It is to be observed that Lord Kelvin does not refer to that part of Diesel's first claim, which states that "the combustion takes place without essential increase of temperature and pressure," nor does he appear to have been in possession of information as to the tests made at Augsburg prior to 1897, tests which showed that it was quite impracticable to suppress the water jacket. Lord Kelvin observes, for example, that "the expansion after the end of the combustion gives a much lower temperature of exhaust without cooling by water jacket than both expansion and water jacket together give in other gas and oil engines." The fact is, of course, that Diesel was never able to run an engine for any length of time *without* a water jacket, and his claims in this respect—as well as the generalisations on which they were based—had to be abandoned.

It is to be remarked that whereas in his report on the Priestman oil engine Lord Kelvin deals with an engine which he had seen at work and examined when opened out after test, the report on the diesel engine deals with an engine which he had not seen. It discloses, as has been mentioned, something of Lord Kelvin's method in examining a patent specification. He goes over Diesel's specification almost line for line and only mentions three earlier patents, those of William Barnett (No. 7615 of 1838), Henry Hoelljes (No. 12,447 of 1889) and Patrick Fraser MacCallum (No. 816 of 1891). Though he does not appear to have made any search, it is clear that Lord Kelvin was of the opinion that before the date of Diesel's patent no other inventor had anticipated the method of introducing the fuel into air previously heated to far above the igniting point merely by compression. He further believes that Diesel was "quite original" in gradually introducing the fuel into the expanding air and so regulating and controlling the temperature produced by the combustion. The report does not mention the Brayton engine of 1872 (Patent No. 432) in which the American inventor explains that "while in the state of expansion consequent upon ignition (the charge) exerts not a spasmodic or explosive force upon the piston, but a true pressure due to expansion, for the reason that the piston is at the very commencement of its stroke when the expanding gas begins to act upon it." It can hardly be doubted, therefore, that Lord Kelvin was unaware of the priority of Brayton in respect of the constant pressure cycle. Had he known of this patent, it would certainly have caused him to point out that in the claim to the constant pressure method of operation Diesel was anticipated by Patent No. 432 of 1872. Brayton, moreover, in his later patent of 1874 (No. 2209) had clearly described air-blast injection of the fuel, since he states that "the essential features of this invention will be embodied in any apparatus which employs a reservoir containing atmospheric air under pressure, and arranged to deliver a charge of air into an induction pipe leading to the combustion chamber of the engine, when such charge of air is made to travel in its course over or through a hydro-carbon fluid, so that the air current can either vaporise and combine with the vapour of the fluid, or take up and bear away the fluid in fine globules to be subsequently vaporised on entering the combustion chamber." It cannot be doubted that this patent of Brayton's anticipates Diesel's Patent No. 4243 (air blast injection) applied for on February 27, 1895, a patent not mentioned in Lord Kelvin's report, which report is solely concerned with what is contained in Diesel's Patent No. 7241 of 1892. The blast-air atomising device described in No. 4243 of 1895 was, however, an essential element on the first workable diesel motor.

The provisional and complete specifications of Diesel's British Patent (No. 7241 of 1892) are extremely prolix in the massing of information, not all of it relevant. After giving a description of some then existing types of heat engines, the inventor proceeds to remark (provisional specification, page 2, lines 16–18) that "The process in gas (petroleum) motor engines (he refers to the process in all engines other than his own) consists in mixing the gaseous or liquid fuel with the air of combustion, in compressing this mixture, in igniting the same and in causing it to expand." This process he later (page 3, line 10) describes as incapable of "essential improvements." In the complete specification (which followed the provisional at an interval of rather more than four months, during which he may have been advised of possible anticipations) he does mention—without naming any specific example—the existence of engines in which pure air is compressed and fuel injected suddenly in the end of compression. Such engines (writes Diesel on page 7, lines 48–51) operate on a process, the characteristic feature of which is: "Increase of the pressure and of the temperature by the combustion and during the latter, and the subsequent performance of work by expansion. The process of combustion after ignition is left to itself." This is just what takes place in the modern engine. Going on to describe his own engine, the inventor states (page 8, lines 54–57; page 9, lines 1–2) that the "characteristic feature" of the Diesel process "remains always as follows:—Increase of pressure and temperature up to about its maximum not by combustion, but prior to the combustion by mechanical compression of pure air and hereupon subsequent performance of work by gradual combustion during an exactly prescribed part of the expansion, characterised by the period of admission of fuel exactly determined by the distributing device."

On page 9, lines 3–12, Diesel remarks that "the combustion itself, in opposition to

all the hitherto known processes of combustion, does not produce any increase of temperature, or at least only an unessential one; the highest temperature is produced by the compression of air; it is therefore under control and will be kept correspondingly in moderate limits; as moreover, the subsequent expansion cools the body of gas in a very high degree, it is obvious that no artificial cooling of the cylinder walls is necessary; that rather the mean temperature of the cylinder contents necessary for keeping the parts tight and lubricated, and in general for the practical working of the engine, is obtained solely by the process itself, whereby also it differs from all known processes."

Diesel had no grounds, in experience, for uttering such words and when the attempt was made to give effect to them in an actual engine, it had to be abandoned after long-protracted, dangerous and costly efforts. Engineering advances by experience rather than by logic and while the imaginative faculties are indispensable, they only lead to rapid achievement when associated with that sagacity which is founded in experience. For example—and no example could be more appropriate—it must not be supposed that Carnot, in his "Réflexions," was advising people on machine design. He was introducing the idea of a cycle of operations and, as Professor Tait remarked, made "the invaluable discovery of the special property of a reversible cycle." The celebrated Frenchman was, indeed, not only intellectual in the very highest degree, but (unlike Diesel) profoundly practical. Diesel would have saved himself and his collaborators a lot of trouble had he apprehended the significance of Carnot's remark that "The economy of the combustible is only one of the conditions to be fulfilled in heat-engines. In many cases it is only secondary. It should often give precedence to safety, to strength, to the durability of the engine."

The truth conveyed in this warning was better understood by the engineers of the Maschinenfabrik Augsburg, particularly Josef Krumper (Ober Ingenieur in the steam engine department) and Lucian Vogel, the latter of whom is known to have made certain designs and calculations for the diesel engine prior to the signing of any agreement between Diesel and the Maschinenfabrik Augsburg. These calculations and drawings are (or were) preserved among the archives at Augsburg. As for Krumper, he it was who appears to have insisted that light oil should be used in the initial stages, not pulverised coal, as contemplated by Diesel.

When, therefore, the description in Diesel's complete specification is compared with the actual engine as finally rendered operable after five years of experimenting, one gets an idea of the labour involved on such men as Vogel, Reichenbach and Lauster, the engineers of the Maschinenfabrik Augsburg, who effected the transformation. The work was long and dangerous (Diesel generously describes it as "selbstlosesten und Hingebendsten") and only after fitting a water jacket, blast-air injection and a lubricator was it possible to demonstrate "the practical working of the engine."

There are two claims in Diesel's patent, only the first of which has any importance: "The method of working combustion motors consisting in compressing in a cylinder by a working piston, pure air, or other neutral gas or vapour together with pure air, to such an extent that the temperature hereby produced is far higher than the burning or igniting point of the fuel to be employed; whereupon fuel is supplied at the dead centre, gradually, that on account of the outward motion of the piston and the consequent expansion of the compressed air or gas the combustion takes place without essential increase of temperature and pressure whereupon, after the admission of fuel has been cut off, the further expansion of the body of gas contained in the working cylinder takes place substantially as described." It is to be noted that regulation or control of the combustion is a characteristic feature, also, that the inventor expressly differentiates his engine from all those in which "the process of combustion is left to itself." A careful reading of Diesel's specification shows that engines in which "combustion is left to itself" are not to be regarded as diesel engines, so that in the light of this specification the modern constant volume direct-injection heavy-oil engine cannot be described as a "diesel" engine.

The contents of Lord Kelvin's report make it clear that before writing his own, he had seen the opinion on Diesel's patent submitted by Messrs. Cruikshanks and Fairweather. These eminent patent agents refer, *inter alia*, to the second claim of MacCallum's Patent No. 816 applied for on January 16, 1891. MacCallum's patent relates—as is well known—to an internal combustion engine in which, among other fuels, powdered coal was to be used. The second claim in the patent is as follows: "In a heat engine or caloric motor actuated by the combustion of powdered fuel, the method of injecting the fuel into compressed air contained in a hot cylinder, or into a hot chamber attached to the cylinder to accomplish the gasification and ignition of the fuel." Lord Kelvin expresses the opinion that Diesel's "process" was not an infringement of the second claim in MacCallum's patent "because this claim, so far as it might be held to anticipate a part of Diesel's process, is itself anticipated by Barnett's patent of 1838 (No. 7615) and by the patent of Hoelljes" (No. 12,447 of 1889).

What Cruikshanks and Fairweather (the report is dated March 13, 1897, eighteen days earlier than Lord Kelvin's and was written by Mr. Wallace Fairweather) said was that MacCallum's "method of working differs from Diesel's in this respect that he does not attempt to attain by compression the temperature necessary for ignition of the charge. In point of fact, the charge of combustible is automatically ignited in MacCallum's engine by the high temperature generated within the cylinder in working. But I see no reason why MacCallum should be compelled to limit the extent of compression of the air supply for his engine. If he follows the accepted theory as established by experiment that increased efficiency is obtainable by raising the compression of the charge, he has merely to lessen the compression space in his engine, and in that event his engine must operate according to the method claimed by Diesel. It results that though Diesel's invention as limited in its scope by the claim is not in actual fact anticipated by verbal description, the claim in the patent probably could not be enforced, because of the facility with which users of existing coal dust engines could vary the degree of compression of the air supply by varying the compression space of the cylinder in well known ways; and therefore the value if not the validity of the patent is doubtful."

Elsewhere in this report, Mr. Fairweather remarks that "If the piston is allowed to travel to within a very short distance of the cylinder end, the degree of compression attainable is only determinable by the capability of the cylinder to resist the pressure; and it could hardly be said that the exercise of inventive ingenuity was required to determine the relative length of cylinder and stroke of piston, or the amount of compression space allowable in an engine to attain the higher efficiency known to be due to increased compression of the charge." Mr. Fairweather (who states that his search did not go back earlier than 1881) points out that there are "a number of gas engines in which the air is subjected to compression independently of the charge of combustible." Like Lord Kelvin, he mentions Barnett's engine of 1838 and Hoelljes' of 1889. But neither Lord Kelvin nor Mr. Fairweather refer to Akroyd Stuart's Patent No. 7146 of 1890 for the compression ignition engine, which patent was already seven years old at the time their respective reports were written. Mr. Fairweather mentions the patent for a coal dust engine granted to Alex Bernstein in 1884 (No. 1457) though he does not regard Bernstein's engine as anticipating Diesel's invention as claimed.

Neither Lord Kelvin nor Mr. Fairweather deal critically with that part of Diesel's patent according to which fuel admission was to be at the dead centre and during part of the return stroke of the piston; this admission being gradual and at a regulated rate so that no essential increase of temperature or pressure takes place after the admission of fuel has been cut off. This regulation or control of the combustion is, however, the characteristic feature claimed by Diesel. It is indeed the feature which, as he expressly states, differentiates his engine from all those in which "the process of combustion is left to itself." No one reading Diesel's specification can fail to see that engines in which combustion "is left to itself" are, by the fiat of the inventor himself, not to be regarded as diesel engines.

When consideration is given to those many patents which, earlier than Diesel's, describe features found in Diesel's patents—as for example, the proposal to burn solid fuel, the constant pressure system, the use of blast air for atomising the fuel, the automatic ignition of the fuel by hot compressed air and the arrangement for air starting—it is truly remarkable that no attack was ever made on the British Diesel patents though Emil Capitaine attacked the German master Patent No. 67,207, of February 28, 1892. Had an attack been made on Diesel's British patent it would almost certainly have succeeded on the ground of want of novelty.

(To be continued)

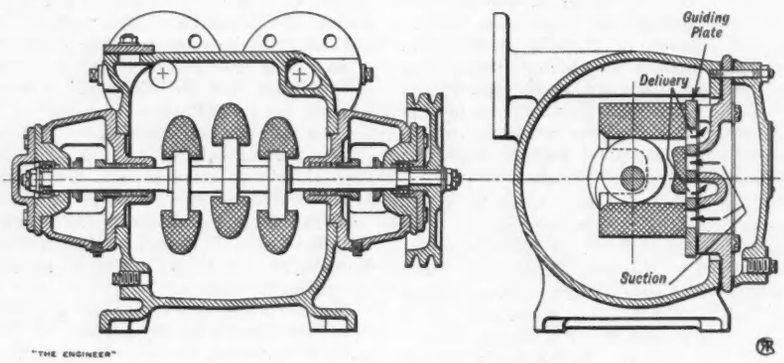
THE SCIENTIFIC FILM ASSOCIATION.—The Scientific Film Association held its third annual general meeting on Saturday, February 8th. In his presidential address Mr. Arthur Elton said that over 2500 copies of the Association's catalogue of films of general scientific interest had been distributed and sold, both here and all over the world. Dealing with the Association's activities and aims, he said these would continue as in the past to be directed along two main channels; the provision of a service to specialists on all matters relating to technical, instructional or research films, and "science for the citizen"—the popular presentation of science and scientific method through the medium of the public cinema. Closely allied to the latter problem was the international exchange of scientific films and the creation of international standards for their examination and critical appraisal. The draft constitution for an International or World Scientific Film Association had already been discussed with the counterpart organisation in France.

Worshipful Company of Shipwrights' Exhibition

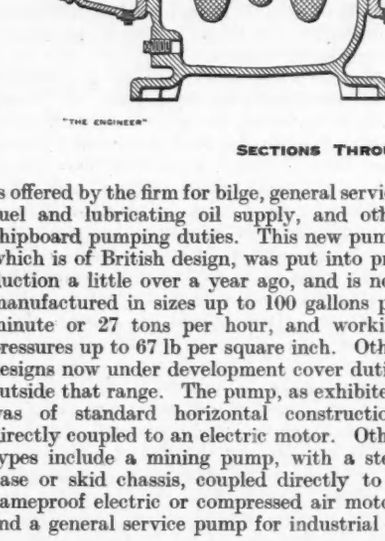
No. IV—(*Continued from page 165, February 14th*)

MEGATOR PUMPS AND COMPRESSORS, LTD.

ON the stand of Megator Pumps and Compressors, Ltd., of Feltham, Middlesex, there was shown a new type of pump, which is offered by the firm for bilge, general service, fuel and lubricating oil supply, and other shipboard pumping duties. This new pump, which is of British design, was put into production a little over a year ago, and is now manufactured in sizes up to 100 gallons per minute or 27 tons per hour, and working pressures up to 67 lb per square inch. Other designs now under development cover duties outside that range. The pump, as exhibited, was of standard horizontal construction, directly coupled to an electric motor. Other types include a mining pump, with a steel base or skid chassis, coupled directly to a flameproof electric or compressed air motor, and a general service pump for industrial or other work, with the motor mounted above the pump, driving it by means of enclosed vee belts.



SECTIONS THROUGH "MEGATOR" PUMP



MOTOR-DRIVEN "MEGATOR" PUMP

All Megator pumps operate on what is essentially the three-throw principle, but the use of modern materials, such as phenolic plastics and natural or synthetic rubber, has simplified the design and transformed the construction.

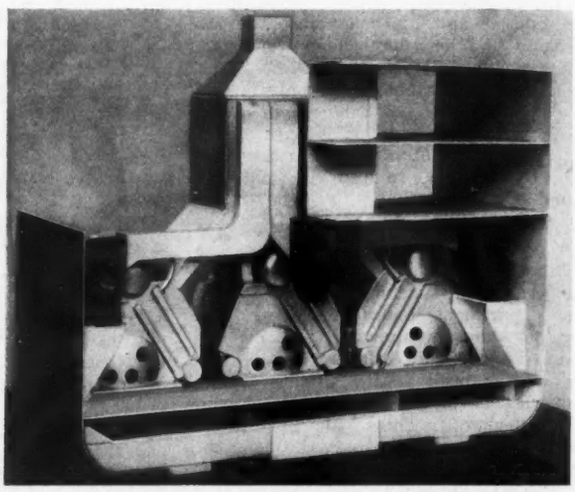
The sectional drawing reproduced herewith shows the design of the pump and its method of operation. The pump body, which is of general cubical shape, with delivery and suction branches, is machined to take two bearing brackets, each with the spindle packing at the inner end, and at the outer end a self-aligning ball bearing which is well away from the gland. The rotor is made of nitrided or hard chromium-surfaced steel and comprises three eccentric discs, spaced at 120 deg. to one another. These discs form the plungers of the pump, and they each work in a displacement chamber or shoe, made of natural or synthetic rubber, with a harder face of phenolic plastic material. The outer ends of the shoes so faced are maintained in contact with the inner surface of the cover plate by the pumping pressure. As the rotor revolves the three discs each travel to and fro in their shoes, thus providing a pumping effect. At the same time the motion of the eccentric discs imparts a vertical sliding movement, which controls the admission and discharge of the liquid being pumped by means of ports in the shoes and the cover plate. The combined displacement of the three discs results in a smooth flow and an even turning moment. In the cover plate opposite each shoe are two inlet ports leading from the suction side of the pump and two ports leading to the interior of the pump body, to which the delivery branch is connected. In the face of each shoe there are also two ports which, as the shoe moves up and down, come alternately opposite the inlet and discharge ports in the cover plate.

An important part of the design is the ease with which all parts of the pump can be inspected without having to break any pipe connections. The shoes can be detached from the discs by removing the cover plate, and if the rotor is to be taken out, it is easily done by removing the ball bearings with their housings and threading Neoprene thrower rings off the shaft, thereby giving access to the packing glands, for repacking or inspection. Finally, one of the brackets can be taken off and the rotor removed.

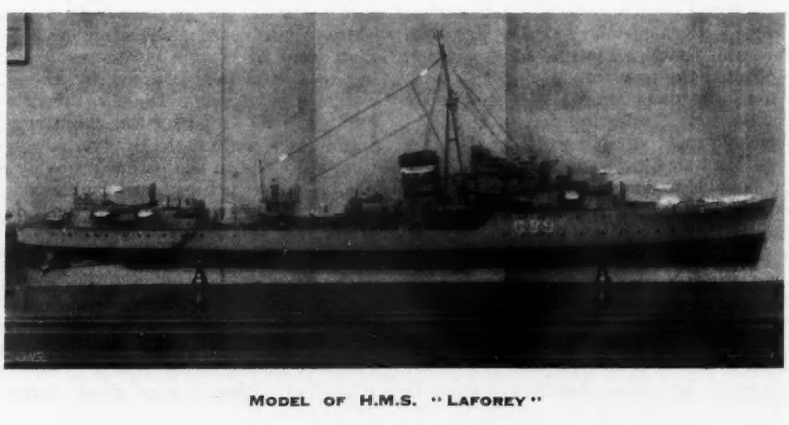
At the exhibition the pump was installed to show its capacity under varying suction and delivery heads, and its exceptional self-priming powers. The performance of Megator pumps in coal mines on "snoring" duties, dealing with large quantities of air and water, often mixed with coal and stone dust, has, we are informed, been most satisfactory under continuous operating conditions. The further development of this novel form of pump for specialised marine duties will be awaited with interest.

YARROW AND CO., LTD.

A prominent exhibit on the stand of Yarrow and Co., Ltd., of Scotstoun, Glasgow, was a model of the flotilla leader H.M.S. "Laforey," which was completed at the firm's yard in August, 1941. She took part in many engagements in the Mediterranean Sea, including the operations at Anzio beachhead, Tunis, Pantellaria and Lampedusa, and operated with the convoys to Malta.



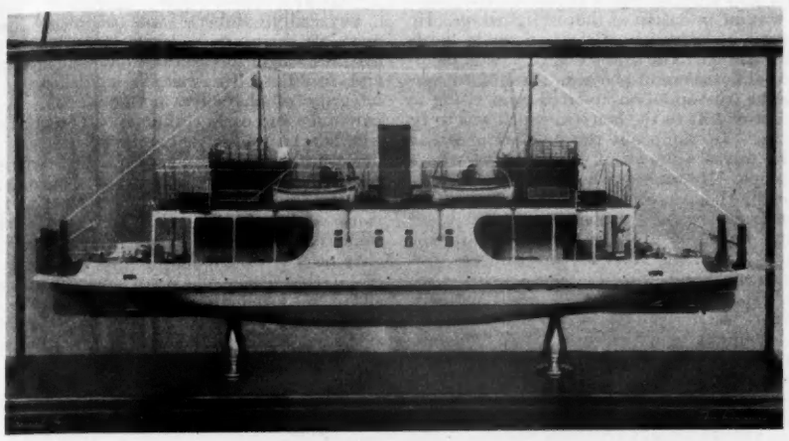
MODEL OF YARROW BOILERS FOR MERCHANT SHIP



MODEL OF H.M.S. "LAFOREY"

She also figured at the landings in Madagascar, and sailed with convoys to Russia. Her loss was reported in April, 1944, while supporting the Nettuno operations.

The principal dimensions of the "Laforey" were:—Length overall, 362ft 6in; beam, 36ft 9in; depth, 20ft 6in; and loaded displacement, 2655 tons. Her main armament comprised three 4·7in guns and one 4in gun, with one set of quadruple torpedo tubes.



MODEL OF OIL-ELECTRIC FERRY

The ship's complement was 15 officers and 235 men. The machinery consisted of a twin screw arrangement of Parsons impulse-reaction geared turbines, taking steam from two Yarrow three-drum boilers with Admiralty type superheaters. The boilers and machinery were built by Yarrow and Co., Ltd., and the total shaft horsepower was about 48,000. The boiler working pressure was 300 lb per square inch and the final steam temperature 660 deg. Fah. A speed of 33 knots was specified, and 35 knots was attained on trial.

Another interesting Yarrow model was that of the sloop H.M.S. "Wild Goose," which was commissioned in March, 1943. The flotilla in which she served was famed for the number of enemy submarines destroyed by it. She has the following principal dimensions:—Length overall, 299ft 6in; beam, 38ft 6in; depth, 17ft 6in; and loaded displacement, 1958 tons. The armament includes three twin 4in guns. The ship's complement comprises 11 officers and 209 men. The ship was built and engined at Scotstoun with machinery consisting of two three-drum Yarrow oil-fired boilers, producing saturated steam at 250 lb per square inch for a twin-screw arrangement of Parsons impulse-reaction geared turbines, having a designed output of 4300 s.h.p. A speed of 19·5 knots was recorded on trial.

A third model showed the double-ended ferry which was built for the Argentine Ministry of Public Works before the war for service on the Parana River. She is propelled by M.A.N. oil engines, coupled to Metro-Vick generators and motors, motors and propellers being arranged at each end of the ship. On trial the engines developed 409·5 b.h.p., corresponding to a speed of 9·37 knots. The model is illustrated above.

The boiler model shown herewith was built to illustrate the general lay-out of three of the latest type of Yarrow three-drum boilers placed abreast in a modern post-war merchant vessel. Actually, this arrangement is adopted in a Furness, Withy and Co. ship now on order. Each boiler is designed for an evaporation of 33,000 lb of steam per hour at a pressure of 470 lb per square inch. The boilers are equipped with Melesco superheaters, giving a final steam temperature of 750 deg. Fah. at the stop valve. The boilers are arranged to work in an open stokehold under forced draught and they have outer air casings. Each boiler is fitted with four oil burners of the pressure type, which are mounted on a spherical boiler front, so that the oil jets converge to a common focal point. Tubular air heaters furnish the heated air for the oil burning, and the heat entrained by the air serves to lower the temperature of the exhaust gases as they pass through the air heater tubes, thereby increasing the efficiency of the heat cycle.

(To be continued)

Richard Roberts, His Life and Inventions*

By H. W. DICKINSON

(Continued from page 178, February 14th)

In 1846 a situation arose closely resembling that which preceded the invention of the mule. The tubular design for Robert Stephenson's railway bridge over the Menai Straits had, after much experiment by Fairbairn, been decided on. Its construction called for large numbers of identical plates having rows of punched holes of uniform pitch for riveting. With the machines then available, punching the holes one by one was the only means possible and this was so tedious and expensive, besides being liable to inaccuracy, that the contractors despaired of being able to finish the job in time. Roberts was appealed to and he responded by producing in a few weeks' time his "jacquard" punching machine, patented in 1847 (March 5th, No. 11,607). It is said that he worked it out while quietly sipping his tea during the evening meal. The throwing in and out of gear of the punches was effected by an application of the revolving prism borrowed from the Jacquard loom. The same machine was used for punching the plates of the tubular bridge over the River St. Lawrence, Canada, as well as elsewhere. What help the machine was is testified to in a holograph letter from Robert Stephenson to Roberts, dated March 25, 1859, containing these words: "Your Multifarious Punching Machine was used at the Conway Tubular Bridge by Mr. Evans, the Contractor, quite successfully, & its advantages over the machines in common use, both as regards accuracy, speed & economy were perfectly established."

The year 1846 saw the expiration of the mule patent and the drying up of that source of income. By this time Roberts had directed his versatile genius into another channel, viz., that of the construction of large clocks for public use, as well as of watches. "He was very fond of Horological studies, and followed with much ardour that imaginary perfection of watchmaking—the remontoire escapement," but his greatest interest was in turret clocks. His improvements were embodied in a voluminous patent with eight sheets of drawings taken out in 1848 (July 17th, No. 12,207), which included also intercommunications of time signals otherwise than by electricity, winding clocks and hoisting weights, &c., by means of the tide. A model of his tidal motor is preserved in the Science Museum. The problem of making a large turret clock is not simply that of increasing the size, because the weight goes up as the cube of the dimensions, causing corresponding friction—that bugbear of the clockmaker. The design and construction of Roberts's clocks were, as might be expected, of a very high class. The remontoire escapement was embodied and the pendulum was compensated. There was one weight to actuate both the going and striking trains and the chain or cord could be taken off in any direction. The hands advanced at intervals of half a minute. The actual striking of the hours was not relegated to the usual irregular fan, but was derived from an independent source.

Roberts never forgot his parents, nor his native place and, believing it would be a public boon, he offered to supply a turret clock to the Parish Church of St. Agatha, Llanymynech, then being erected, the only condition being that one face should be visible from the quarry where he had worked, so that the quarrymen should know the time. The clock was installed in 1845 and still continues to tell the hours. These were days of prosperity with Roberts, and he built a stone cottage for his aged father at Garthwydd, in the village of Pant, on the site of a thatched cottage occupied by his grandparents that had been burnt down. Here, known as Prospect Cottage, still existing, his father lived till his death on May 19, 1851; his mother had died in 1802 in Liverpool and lies buried with two of her daughters in St. John's churchyard.

Incidentally, we may mention that the making of these clocks became quite an industry, which later was taken over by John Bailey, his foreman mechanic; this was the beginning of the business of the well-known firm subsequently so well known as Sir W. H. Bailey and Co., of Salford.

The partnership with Fothergill and Dobinson was dissolved in 1851 or thereabouts, for what reason we do not know, but we surmise the business had not been successful and that Roberts probably lost money. He continued at the Globe Works under his own name, but gave up actual manufacturing in 1854 or 1855 and started as a "machine agent and consulting engineer" at 30, Brown Street, Manchester. We have not learnt how he disposed of the works, but they appear to have been closed. Fothergill appears in the "Directory" in 1855 as a "consulting engineer."

Roberts was an exhibitor under his own name at the Great Exhibition of all Nations in Hyde Park (the Crystal Palace) in 1851. His exhibits were:—

Patent alpha (church or turret) clock.

Watch which beats dead (centre) seconds with only one train of wheels.

Patent recorder watch with double hands.

Patent normal drill.

Patent synchronometer model.

Patent wheel sector.

Electromagnet, 2½in square, the iron of which only weighed 1 lb 4½ oz, capable of sustaining upwards of 500 lb.

Ditto, 3in square, weighed 2 lb 6 oz, capable of sustaining 678 lb.

The clock—why he named it "Alpha" we do not know—was one of the kind described above. The watches were those patented in 1848 (July 11th, No. 12,120). The normal drill was for drilling watch plates and was what we should now call a jig—an example is preserved in the Science Museum and another at the Horological Institute, London.

The synchronometer model was "to show by the application of pneumatics how a clock may be made to indicate simultaneously the time of day on dials in various places at a distance from

* The Newcomen Society, November 13, 1946.

each other." This likewise was included in the 1848 patent.

By the wheel sector "the external and pitch line diameters of wheels and pinions of any pitch or number of teeth are accurately ascertained." Apparently this instrument was an invention of his early Manchester days. We shall be interested to know if one is still in existence and what was its mode of construction and use. The electro-magnets we can suppose to have been the outcome of Roberts's cerebration caused by the discoveries of William Sturgeon (1783–1880) in 1823. The latter became superintendent of the Victoria Gallery of Practical Science at Manchester about 1849 and must have met Roberts at the Literary and Philosophical Society. One of these magnets is in the Science Museum, London, and another such in Peel Park Museum, Manchester. For his exhibits at the Crystal Palace Roberts was awarded a prize medal.

In 1852 or earlier he turned his attention to the accessories and constructional details of vessels—what induced him to do so we do not know—and took out in that year a patent (May 22nd, No. 14,130) fecund with ideas for which there were no less than thirty-three claims. The inventions described comprise:—Turbine (*i.e.*, a centrifugal pump; steam generator; masts; spiral-shanked anchor; railway and wagon; spiral vane propeller; bowlines; windlass; ship ventilator; steam packet ship (twin screw); lifeboat and lowering tackle. Like so many inventors, he brimmed over with ideas, but did not always get down to the prosaic and dull task of working them out into a form which would command acceptance—that is, if they were not too far in advance of or in opposition to existing practice to be adopted—before he was off again on another track. The twin-screw vessel was a case in point, for it was many years later before, with higher speeds and consequent greater horsepower, it became a necessity. We could almost wish that he, like Edison, had had a team of assistants to ease his birth pangs. He published a brochure on these inventions and it may be that it was with the idea of pushing this patent that he came to London and established himself as a "consulting engineer" at 10, Adam Street, Adelphi. His devoted daughter accompanied him and kept house for him. On his removal the Literary and Philosophical Society, in April, 1861, made him an honorary member.

In 1853 he took out a patent for the construction of iron casks to facilitate stowage; they were made in halves or quarters along the diameter or the axis. We do not learn that this invention was brought into use. The following year was a still more prolific period, for in it he took out no less than five patents: one for cutting pasteboards and other materials, another for punching, drilling and riveting and three for preparing fibres for spinning. His fecundity, contrary to what is usually noted with respect to inventors, seems to have increased rather than diminished with advancing years. In 1835 a patent for power looms followed. In 1856 the continually widening area of the Metropolis called for an extension of means of passenger transport. The horse bus was then the only means available—the District Railway having not yet come into being—and this led to the enterprise of the London General Omnibus Company, a combine which took over on January 7, 1856, twenty-five existing businesses. The directors offered a prize of £100 for the design of an omnibus best suited to their requirements. There were seventy-four competitors, among whom was Roberts.[3] The judges awarded the prize to Mr. R. F. Miller, with this reservation: "We find no design that we can recommend for adoption intact, or which, to speak truly, is worth the premium offered; but there are points about some of them which being combined would act in producing what you and the public desire—a light commodious and well ventilated omnibus." As an outcome, the company's new omnibuses were built from a design that combined the best points of several competitors, among whom we believe Roberts to have been one. He patented his bus in 1856 (April 2nd, No. 792).

Another patent followed in 1857 (June 5th, No. 1579) for weaving and folding fabrics. In 1858 he showed a fundamental departure from previous inventions by patenting (March 11th, No. 488) improvements in mechanism for line engraving designs on flat and curved surfaces of metal, paper and other materials, such as are required in calico printing.

In 1859 he took up the subject of pharology or lighthouse construction and on March 8th read a paper on his ideas at Manchester. His idea was an extension of that of lightships. He proposed a succession of floating guide lights in the seaway. The tower was to have a hemispherical bottom and above water its form was to be the frustum of an inverted cone, rising to a height of 45ft to the lantern, which was to be dioptric. To damp out the oscillation caused by the waves a fly-wheel was to be used as a gyroscope. He took out no patent for this, as obviously the idea could have been worked out in different ways. Roberts submitted his marine inventions to the Admiralty, to the French and to the Russian Governments, but nothing came of it.

Roberts's last patent, only a provisional one, however, was for marine steam engines, taken out in conjunction with Captain T. E. Symonds, with whom he appears to have shared office accommodation.

We have mentioned inventions patented, and unpatented, by Roberts, but there remain others which we may rather class as discoveries than inventions, and these deserve a short notice. In October, 1824, he observed the phenomenon of a stream of air issuing from a pipe causing a plate held in front of the mouth to be sucked back. He showed the experiment to members of the Literary and Philosophical Society and to Mr. M. Clement Desormes, of Paris, who was visiting the town. An assistant, T. Hopkins, made further experiments in September, 1826, and read a paper before the Society on "Experiments and Observations on Diverging Streams of Compressed Air," on March 9, 1827. In 1842 the fact that the credit for making the observation had been awarded to Monsieur Desormes elicited a letter from Roberts stating the facts.

In 1835, at the British Association meeting at Dublin, he exhibited two instruments "which render objects visible while revolving 200,000 times a minute," depending on the persistence of vision—in fact, a stroboscope. In one instrument the aperture for the eye was made to travel through 180ft between every two inspections of the moving object, such object being made to assume a different position at each successive inspection; in the second instrument the object was seen successively in the one position only.

He seems to have been fond of attending the British Association, for he was at Swansea in 1848, where he showed a new kinematic element, and at Hull in 1853. To the Patent Museum, in 1859, he presented a pair of skew wheels on non-intersecting axes, showing his interest in the subject.

We could go on at greater length on the subject of his discoveries and inventions, but we must bring this tale to a close. His amazing record of twenty-seven patents, taken out in twenty-eight years, although it fades into insignificance compared with subsequent records of other inventors, especially in U.S.A., must surely have exceeded that of anyone up to his time, particularly as before the new Act of 1852 many of them were omnibus patents, comprising a number of distinct inventions.

Roberts's resources gradually dwindled; Sir W. H. Bailey says that he became involved through some of his multifarious inventions in his later days, particularly those connected with steamships; others say that he lost money through the liquidations of assets due to the cotton famine during the American Civil War. Whatever it was that happened, he got into low water, but his pride prevented him from disclosing the fact, except to such intimate friends as his pupil, Charles F. Beyer, and then only partially. When the situation of affairs leaked out, a committee comprising Lord Brougham, Sir James Kay-Shuttleworth, Sir William Fairbairn, Sir Joseph Whitworth, Mr. Chares F. Beyer, John Ramsbottom, C. P. Stewart, John Platt, John Cheetham, Matthew Curtis, Edmund Ashworth, with Mr. David Chadwick, M.P., as secretary, was formed. The amount promised was considerable, but the hand of death intervened on March 11, 1864, and the money raised was applied to the purchase of an annuity for his daughter, who, in addition, received a Civil List pension of £200 in recognition of her self-sacrificing devotion to her father.

Physically, Roberts was of heavy build, over 6ft high, with large strongly marked features, high forehead, prominent eyebrows and full lips. He was distinguished by his integrity of character, no doubt due to his parentage and early training; we do not know whether he had strong religious views. He never lost his Welsh accent. He had a remarkable memory and great powers of concentration. Nothing bearing on mechanics escaped him, being absorbed by him ready for use when wanted. His skill in handicraft was so great that he was said to be able to file a cube of metal true without the aid of square or straightedge. He loved his work for its own sake and pecuniary reward was only a secondary consideration with him, hence his undeserved lapse into poverty in his old age.

We conclude in full agreement with the panegyric of Mr. Lang:[4] "It is not too much to claim for this great man that although our country's records are full of the names of eminent engineers, the name of Richard Roberts stands for that of the greatest mechanical inventor of the nineteenth century."

[3] Moore, H. C., "Omnibuses and Cabs," 1902, page 80.

Frequency Modulated Broadcasting

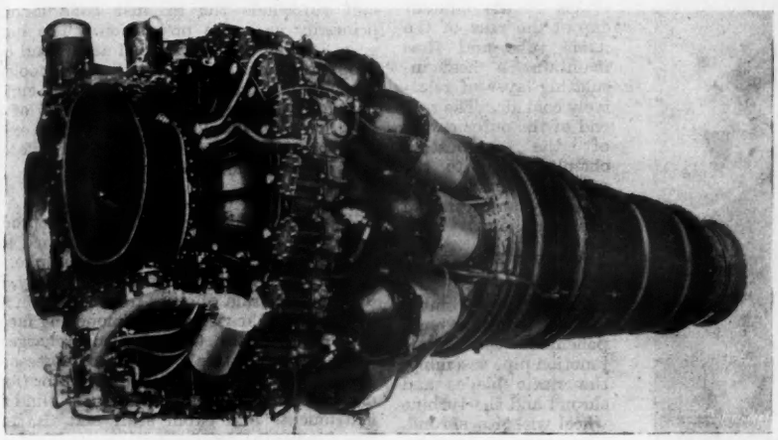
THE announcement that Marconi's Wireless Telegraph Company, Ltd., are to supply a 25-kW frequency modulated broadcasting transmitter to the B.B.C. marks a significant development in the history of British broadcasting. It has been known for some time that the B.B.C. were taking a keen interest in frequency modulated broadcasting and have been conducting experiments. Frequency modulation offers several advantages over the present system, which is known as "amplitude modulation," the outstanding advantages of the new system being greatly improved quality and lack of background noise. This new Marconi transmitter will be the first frequency modulated transmitter to be put into regular service by the B.B.C. and will embody some notable improvements in the art. This is the first major step towards the adoption of the new system in this country. The transmitter will be built at the Chelmsford works of the Marconi Company, where twenty-five years ago the B.B.C.'s first transmitter, the famous 2LO of the Savoy Hill days, was built.

£300,000 RADIO CONTRACT FOR BRITAIN.—The largest single order for wireless equipment which China has ever placed has been secured for Britain by Marconi's Wireless Telegraphy Company, Ltd., of Chelmsford. Valued at nearly £300,000, the contract covers the supply of twelve telegraph/telephone transmitters varying in power from 5 kW to 25 kW, which are designed for use on the international telephone circuits. In addition, thirty triple-diversity high-speed receiving equipments and 150 commercial receivers are to be supplied. This new equipment has been ordered as part of China's plan for the extension and reconstruction of her telecommunication services, and follows on a previous order placed with Marconi's some months ago for radio equipment of a similar nature to augment China's internal services. Special steps have been taken to ensure that this equipment will be despatched within the next twelve months and thus form part of Britain's current export total.

[4] *Beyer-Peacock Quarterly Review*, Vol. III, No. 2, page 56.

De Havilland "Ghost" Jet Aero-Engine

IN our annual review article on aeronautics, published in January, a brief description of the de Havilland "Ghost" jet-propulsion aero-engine was given. We are now permitted to publish further details of this powerful jet unit, which is rated for 5000 lb static thrust. Successor to the "Goblin" engine, the "Ghost" is similar in general lay-out, but with thrust rating increased from 3000 lb to 5000 lb. This substantial increase has been obtained at the expense of an increase in overall diameter of



DE HAVILLAND "GHOST" JET AERO-ENGINE

only 3in, the diameter of the new unit being 53in. At 600 m.p.h. at sea level the rating of the "Ghost" is equivalent to 8000 true thrust horsepower, or to 12,000 h.p. from a corresponding piston engine, assuming a propeller efficiency of 66 per cent. Moreover, this is only the initial rating, and it can be assumed that further development will lead to still higher ratings.

Design Considerations

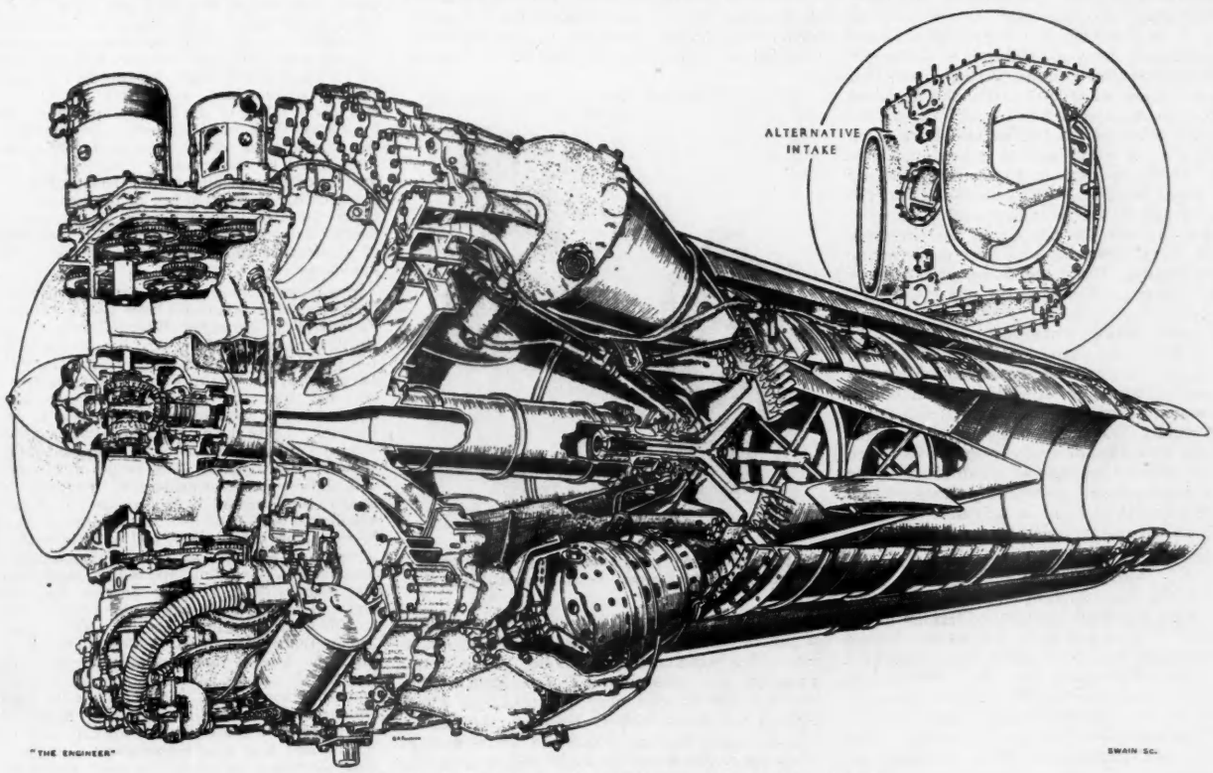
Though generally similar to the "Goblin" engine, improvements in design have led to an improvement in fuel consumption, which is now quoted as 1·06 lb per pound thrust per hour, some 15 per cent better than that of the "Goblin." When the "Goblin" was designed, emphasis was placed on high performance when installed in fighter aircraft of the "Vampire" class, but in the design of the "Ghost," which was not started until late in 1943, emphasis was shifted to a greater extent upon performance with minimum fuel consumption, with a view to its installation in civil aircraft and in types of service aeroplanes other than the fighter. In fact, it is understood that already it has been decided to install a pair of these engines in the outboard nacelles of an Avro "Lancastrian" machine for long-range and endurance trials. This is not to say that the "Ghost" is not suitable for the high-speed interceptor aircraft, for experimental engines will be fitted into the "Vampire" airframe for high-speed tests. Indeed, the firm claims that the effective thrust in a compact single-turbine fighter aircraft is greater than that of any other gas turbine yet manufactured.

The basic lay-out employed comprises a high-velocity ducted intake feeding a single-sided impeller, a straight-through combustion system, and a single-stage axial turbine with direct ejection. This design is stated to ensure the shortest, simplest, stiffest engine obtainable within a given cowled diameter. A compact engine with a minimum divergence of gas flow is clearly necessary when handling more than 140 tons of air per hour, compressing, heating and expanding it and ejecting it at a nozzle velocity of well over 1000 miles an hour. Some impression of the capacity is given by the fact that the "Ghost" consumes about twenty-six times as much air as a 2000 h.p. piston engine. About 9000 h.p. is developed in the turbine shaft to compress this quantity of inhaled air.

Important advantages are claimed for the direct ducting of the air to the front face of a single-sided compressor, especially at high flying speeds. Pressure losses are reduced to a minimum and an increased air flow is obtained. Nearly 95 per cent of the available ram effect is obtained in the "Ghost" without creating difficult air flow repercussions. The high-velocity ducted intake reduces aircraft drag and minimises internal disturbances common with other systems. An efficient air intake can be blended into the framework of the aircraft. The direct ducting to the front of the impeller is claimed to eliminate the preheating of the air which takes place on the rear face of the double-sided type, and the cooler air being denser gives better engine performance. Alternative types of intake are available to suit different types of installation, as is indicated in the photographs and sectional perspective view reproduced herewith.

The simple rigid rotating component has design advantages again derived in part from the single-sided impeller. The two opposing thrusts can be conveniently balanced by mounting impeller and turbine rigidly on a shaft in tension, leaving only a small residual thrust to be taken by a single locating bearing. In the "Ghost" a tubular main shaft of large diameter, with impeller and turbine wheel mounted directly on it, gives a particularly rigid structure.

With this simple engine lay-out a robust structure is readily obtained. The main shell is a steel cone stiffly united to the steel assembly

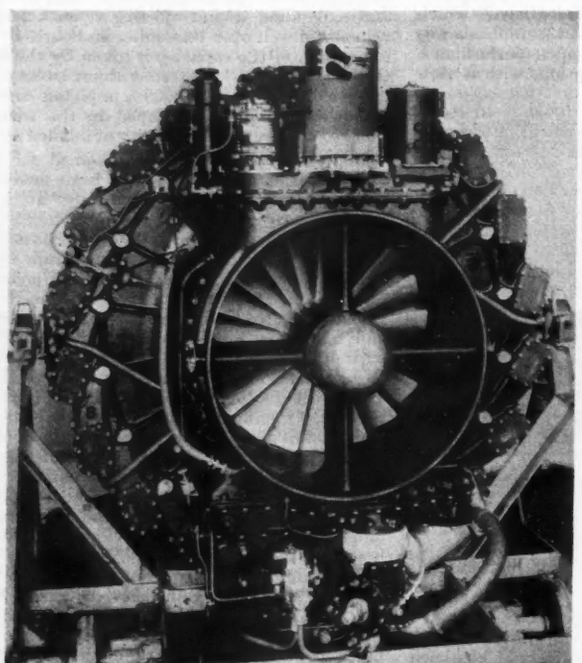


CUT-AWAY VIEW OF "GHOST" JET PROPULSION UNIT

of the rear turbine bearing. The main cone, or centre casing, is carried by steel bolts which pass through the diffuser casing to form pick-up points and thereby provide front cantilever mounting essentially like the conventional braced mounting for a radial engine.

Compressor, Rotating Shafts and Bearings

Air enters the impeller axially at the forward side through ducts in the air intake casting.



Axial Air Intake and Accessory Gearboxes

In the impeller the air is compressed and turned through an angle of 90 deg. so that it is discharged radially from the impeller periphery into discharge passages cast in the diffuser casing. Here the velocity of the air is decreased and its pressure increased before it is discharged into the combustion system. At the maximum rotational speed of 10,000 r.p.m. the designed compression ratio is 4·25 : 1. The air intake forms the front of the engine and contains a housing for the front bearing assembly. The diffuser casing is cast in two pieces, the air intake being bolted to the forward end and the centre casing to the rearward end. With the axle-entry intake the casting is now in magnesium. Magnesium has also been used for the impeller casing. This metal is reported to have already given good service in the "Goblin" engine.

The centre casing, which is a conical support of steel, can be considered as the backbone of the engine ; it is bolted at its rearward end to the rear bearing housing. A sealing plate, bolted to the rear diffuser casing, contains a number of concentrically arranged labyrinth grooves matching with similar grooves on the rear face of the impeller ; leakage of air down the rear face of the impeller is reduced by these grooves and their radial position is such that the axial thrust of the rotating assembly is eliminated.

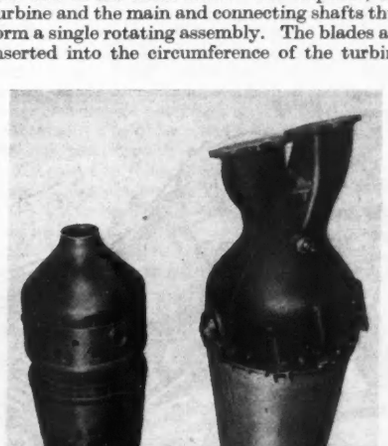
Combustion System

The combustion system comprises ten large combustion chambers (instead of sixteen in the "Goblin"), each with an atomiser burner supplied with fuel from the burner manifold. There are twin entries to each combustion chamber connecting to the diffuser passages. Two of the combustion chambers some distance apart contain bosses for injection igniter plugs, and the individual combustion chambers are interconnected, so that after ignition the flame can spread to all the chambers. An illustration is given herewith of the "flower-pot" shaped flame tube, made of heat-resisting steel, and of its outer casing. The burner passes through the centre of the dome head of the flame tube, which also provides a metering orifice for the air required for primary combustion. By far the greater proportion of the air delivered from the diffuser, however, flows over the head through the gap between the flame tube and the outer casing, entering the flame tube through secondary holes and diluting the combustion products so that the temperature may be kept within the necessary limits. A small proportionof the air continues to the annular gap at the rear of the flame tube and thus maintains a heat insulating layer of relatively cold air. The rear end of the outer casing of the combustion chamber fits into the nozzle junction pipe assembly and forms an expansion joint.

Turbine Assembly

Considered as part of the turbine assembly are the following components : the nozzle junction pipe assembly, the static blades and shroud and the turbine wheel with its shroud. The nozzle junction pipe assembly, which is supported by a diaphragm mounted on the rear bearing housing, acts as a collector of the combustion gases before they are guided by the static blades to the turbine blades.

The turbine disc is made of heat-resisting steel and incorporates an integral hub shaft which is splined to the extension shaft at the rear end of the main shaft. The impeller, the turbine and the main and connecting shafts thus form a single rotating assembly. The blades are inserted into the circumference of the turbine



"Flower-Pot" Flame Tube and Combustion Chamber with Twin Ports

disc by fir tree roots. The blades rotate within a turbine shroud ring attached to the static blade ring, which is itself attached to the nozzle junction pipe assembly. The position of the turbine shroud assembly is stabilised by a cylindrical drum bolted between the nozzle junction pipe assembly and the centre casing. This drum also transfers loads arising from the exhaust cone assembly to the centre casing.

Exhaust Cone Assembly.

This assembly is made of stainless steel and is bolted to the turbine shroud. It consists of an inner cone and an outer cone with propelling nozzle attached. A heater muff is welded to the exterior of the outer cone so that air from an external source can be passed through this muff and used for warming the cabin and the gun mechanism.

Air leaves the turbine blades in an axial direction and is directed and expanded in the exhaust cone assembly to form the propulsive jet. A thermo-couple inserted in the exhaust cone assembly in the neighbourhood of the emerging jet enables the pilot to control the engine within the stipulated operational limitations.

When the engine is installed, a metal lagging cuff surrounds the exhaust cone assembly, primarily as a fire precaution. The hot jet gases leaving the venturi cuff at the end of the propelling nozzle induce a flow of cooler air through the annular space between cuff and nozzle by ejector action, and this flow of air is effective over the whole length of the exhaust cone assembly, also serving to ventilate the engine bay in the aircraft.

Wheel Cases and Sump

As is indicated in one of the views reproduced herewith, two wheel cases are attached to the top and bottom of the air intake, the accessories, which are mounted vertically, being driven by a train of gears from the main shaft. The top wheel case contains mounting faces for the starter motor, the cabin supercharger (for cabin pressurisation), the air compressor (for brakes), a 1500-watt, 24-volt generator (for aircraft services), a vacuum pump (for blind flying instruments and cabin seal) and the engine speed indicator generator drive ; and the bottom wheel case contains mounting faces for the fuel pumps and the hydraulic pump. Attached to the bottom wheel case is the oil sump which contains a gear type pump. Metering pumps supply a metered quantity of oil to the front and rear bearings.

A Filtration Exhibition.—The exhibition of filtering equipment made by Vokes, Ltd., of Guildford, which was arranged to open on February 17th at the showrooms of the Bristol Aeroplane Company, Ltd., at 69–70, Piccadilly, W.1, was postponed owing to the power cut. It was officially opened on March 3rd and will remain open to the public from 9 a.m. to 1 p.m. and 2 p.m. to 6 p.m. daily until March 14th (Saturday and Sunday excluded). In this little exhibition can be seen a representative range of the sizes and types of air, oil and fuel filters made by the firm for aircraft and many branches of industry. The principal features of many of the exhibits are shown clearly by the use of a number of sectionalised models, and the arrangement of the associated components in their order of construction. Although a certain amount of the specialised work done during the war is featured, the main object of the exhibition is to direct the attention of visitors to the use of the firm's products in normal times, and the wide field of application which exists for its many filtering appliances.

Research Laboratories for Instruments.—New research laboratories have been established at Elstree Way, Boreham Wood, Herts, by Elliott Brothers (London), Ltd. In its history of nearly 150 years, this firm has been responsible for many advances in the realm of measuring instruments, and has had the distinction of manufacturing apparatus for such eminent scientists as Michael Faraday. Up to the present, the research laboratory has been an integral part of the Company's Century Works at Lewisham. The scope of its activities will, however, be considerably extended in the modern building of 50,000 square feet floor area, which will house the new laboratories at Boreham Wood. This organisation will undertake the development of all types of industrial and laboratory instruments, including specialised equipment for the Admiralty and other Service Departments, and will also develop new techniques for the control of manufacturing processes. The laboratories are in the charge of J. F. Coales, O.B.E., M.A., M.I.E.E., late of the Admiralty Signal Establishment. Mr. Coales has made a number of original contributions on the subject of radio direction-finding, and, with the advent of radar he was the leader of a research team working on decimetre waves and was also responsible, throughout the war, for the development of radar for gunnery in H.M. Ships.

Electrical Research Association

THE annual general meeting of the British Electrical and Allied Industries Research Association took place in London on Friday, February 14th. At the luncheon which followed, the toast to the E.R.A. was proposed by Sir John Dalton (**general manager of the County of London Electric Supply Co.**) in the absence of the Minister of Fuel and Power, who was unable to attend. Sir John made some pointed remarks on research and nationalisation. He reminded his listeners that the electricity supply industry, as now constituted, made substantial and regular contributions to the funds of the E.R.A., which undertook research in matters concerning electricity supply. Under the proposed new regime for the supply industry research was to become one of the functions of the "central authority." This unnecessary change was evidence of hurried legislation which suggested that those who were responsible for preparing the Bill were unaware of the existence and functions of the E.R.A. Sir John wished that Mr. Shinwell might have been present to avail himself of the opportunity of explaining why the change in responsibility for research was contemplated, and how the E.R.A. might be compensated, for the loss of income derived hitherto from the supply industry. It would be deplorable if this loss **delayed the establishment** of the new research laboratories at Leatherhead.

Responding to the toast, the President, the Earl of Mount Edgcumbe, echoed these fears about the fate of research, and expressed the hope that the reference in the Electricity Bill relating to the "promotion" of research would not come to be construed as "meddling with" research. He had always been keenly interested in the activities of the E.R.A., and as a user of its researches he was in a good position to judge the value of its work. The Association was no mushroom growth, but had expanded steadily, and the scope of its researches increased by 100 per cent every eight years. The importance attached by industry to the E.R.A. could be assessed by the fact that it was actively supported by 80 per cent of the industries concerned. Many foreign countries had shown increasing interest in the organisation and work of the Association. Emphasising the importance of effective research in this country's future well-being, the speaker drew attention to two aspects of the E.R.A.'s work. First there was the important task of promoting and assisting fundamental research on such subjects as dielectrics, for example. Secondly, there was the task of closing the gap between pure and applied research, so that the resulting discoveries would be available to industry in usable form.

Annual Report

The twenty-sixth annual report covers the period October 1, 1945, to September 30, 1946.

To make a general assessment of the year's progress, it is helpful to recall that the E.R.A. is organised for the co-ordination of many interests. For example, as stated in the introduction to the report, the Association maintains continuous liaison with the research organisations of all the relevant leading manufacturing firms and industrial associations, numbers of whose technicians serve on its ninety-odd specialised committees, and provide invaluable guidance on the practical aspect of its investigations into the more general scientific basis of industrial development.

During the year considerable progress has been made towards more permanent financial arrangements with the Ministry of Supply and the Admiralty. Technical co-operation with these departments, as well as with others, including the Ministry of Fuel and Power, has been successfully pursued without neglecting the effort towards closer relations with older associates, such as the D.S.I.R., the Post Office and the Electricity Commission.

Increased assistance has been forthcoming from the National Physical Laboratory on whom the Association depends so much for scientific help. At the same time, arrangements with universities have been extended so that the Association is now promoting research programmes at the majority of British universities, particularly at Bristol, Cambridge, Liverpool, London, the Imperial College and Sheffield.

The Association's long-term plans are based on the projected establishment at Leatherhead. Small scale plans for this project have been approved by the Council's Laboratory Committee, while the building scheme has received Government approval. Larger scale plans and estimates are now being prepared on the basis of which licences for labour and materials will be requested. The scheme will involve considerable capital costs initially, and increased annual expenditure later. Accordingly, special capital contribution, together with increased annual contributions, must be envisaged.

Research Programmes

With the continued support of the great majority of the important electrical interests steps are being taken to extend the range of the Association's technical services. For example, a new section has been formed to deal with the grindability of coal; re-organisation has produced three new or modified sections on insulated cables, overhead lines and on security problems including earthing; and the Council has called for a report on new fields in light current engineering. During the year, research facilities in general have been greatly improved by a number of new installations, including an X-ray structure analysis equipment, and by a considerable accession from Government disposals of apparatus, machine tools and equipment.

In the space at our disposal it is impossible to do more than to indicate in general terms the scope of the numerous researches, a full account of which is contained in the Association's report. It is interesting in the present state of knowledge to compare the results of the Association's substantial efforts in two different fields—switchgear and dielectrics. Progress in switchgear practice, depending on gas-blast and oil-blast methods of arc control, has owed much in the past to experiment and empiricism; it is only recently that basic theoretical progress has been made. In the study of dielectrics, on the other hand, E.R.A. has made great progress in fundamental theory. A large part of the theory of dielectric breakdown is now known; the outlines of the remainder have been clearly drawn. The general picture of dielectric properties has been filled in and their qualitative dependence upon molecular or solid structure is clear, while in some sections a truly quantitative theory of electric properties in terms of solid structure exists.

The Physics of the Arc

Definite progress has been made during the year towards the resolution of the problem of discharge in gases from a number of aspects. The characteristics of short glows and arcs in spark formation are nearly determined. Real progress has been made in research on the physics of the arc; the application of this study to welding owes much to the substantial contribution made by the Welding Research Association. Some results have been obtained on short sparks in high-frequency ignition, while the statistical study of explosive ignition in "flameproof" equipment is substantially complete. Extramural work is in hand on high-speed photographic studies of spark formation, sparkover and corona at the highest frequencies. Other aspects are discharges on the terrestrial and even cosmical scale. A quantitative basis has been established for the severity of lighting conditions as a statistical probability, together with the study of methods of protection to reduce the hazard to small proportions.

It has been decided that the essential data should be obtained as soon as possible for a further substantial rise in steam temperatures and pressures for turbines and work to that end, particularly on alloy steels, has been put in hand. Arrangements have been made to start work on the grindability of coal. At the same time the development of a novel type of storage cell has been put in hand at Cambridge.

Research is continuing with new techniques on permanent magnet alloys, transformer steel and cadmium copper conductors. Together with the study of dielectrics already mentioned and special studies such as moisture resistance and ionization of paper, the Association's research on materials covers all three categories, insulating, conducting and magnetic.

During the war, work relating to systems and installations was necessarily curtailed but these researches have now been intensified. Among topics where an interim or final stage has been achieved are: rating of insulated cable in ships, rating of overhead lines, a hand-book of the electrical characteristics of overhead lines, a summary of researches on earthing with the possibility of a code of practice in due course. Staff has been allocated full-time to system analysis and the design and use of network analysers. Tests on an important electric railway have indicated the interest attaching to the dephasing of rectifiers supplied from an a.c. system. In radio interference the Association may claim a substantial degree of success in overcoming the remaining technical difficulties in the general introduction of correction both on land and sea.

After a good deal of negotiation and discussion, steps have been taken in two matters of immediate interest to supply engineers. Promise of adequate support and facilities has been received for large scale experiments on the statistical nature of the demand from domestic consumers equipped with varying types of appliance. Secondly, a committee has been formed to study those scientific and technical factors which enter into the bases of various tariff structures. Meanwhile existing programmes on the technology of consumer supply have been accelerated.

In the topical problems of space and water heating, interest has lain mainly in the use of the heat-pump method, the better utilisation and design of water heaters and in the applications of the basic principles of transient heating which the Association has already made clear.

The E.R.A. agricultural station at Shinfield Green is now in effective operation, although naturally it has only been possible to cultivate a small part of the ground. The main researches in hand are on crop drying, soil heating, wind generators and hammer mills.

German Scientists

Under a scheme, which has received wide publicity, the Government can offer selected German scientists voluntary limited contracts of employment for service to British industry. The salaries and certain expenses are paid by the Government. The Association accepted the responsibility of organising the scheme for the electrical industry and prepared lists of persons whom representatives of the appropriate sections of the industry thought suitable. To organise and control in the general interest the work of the scientists selected, two special Committees have been set up, one on ceramics and another on high-voltage direct-current problems. Existing committees, such as Section G: Switch and Control Gear, have in other instances been charged with similar responsibilities.

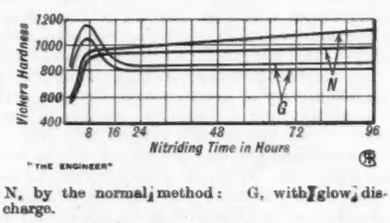
In addition, the Association has organised or participated in a large number of interrogations of German scientists. Recently, at the request of the Government, the E.R.A. has undertaken to secure the preparation of reports to give an overall picture of the situation of the German electrical industry in comparison with Great Britain to assist in appraising the needs of our industry from an international standpoint.

Metallurgical Topics

Attempts to Accelerate the Nitriding of Steel

GREAT improvements in machine construction have been made possible by the nitriding of steel surfaces, but the time taken in the process and the limited thickness of case economically obtainable have been regarded as disadvantages. Many attempts have therefore been made to attain the great hardness of the nitrided layer in a shorter time or to produce thicker and more strongly attached layers without losing the advantage of high hardness.

To what extent such experiments have been successful or have given promise of success has



N, by the normal method: G, with glow discharge.

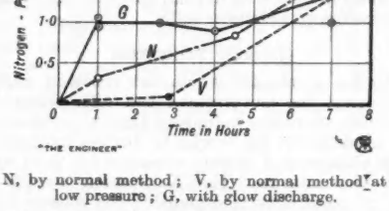
In each case the upper curve represents maximum hardness and the lower curve surface hardness.

FIG. 1—*Effect of Duration of Treatment on the Hardness of the Nitrided Layer in Chromium-Aluminium-Molybdenum Steel Nitrided at 500 Deg. Cent. (Bennek and Rüdiger)*

been discussed by E. Kunze[1] and another new method of accelerating the process has been suggested by H. Bennek and O. Rüdiger.[2]

The treatment of iron by molecular nitrogen leads to only a very small nitrogen content in the surface layer and gives no technically useful increase in hardness. The affinity between iron and nitrogen is very slight compared with the energy required to split a nitrogen molecule. An immediate reaction, however, takes place in the presence of atomic nitrogen, but there is a continual re-forming of nitrogen molecules which proceeds with greater velocity the higher the nitrogen content of the surface layers.

The essential problem of nitriding is therefore to produce atomic nitrogen at the surface at the most suitable temperature of treatment. This object was attained by the use of ammonia



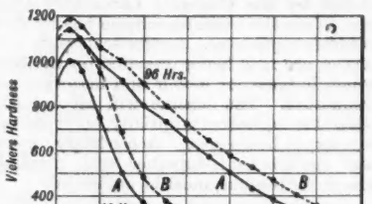
N, by normal method; V, by normal method at low pressure; G, with glow discharge.

FIG. 2—*Effect of Conditions of Nitriding on the Nitrogen Content of 1 Per Cent Chromium Steel. (Bennek and Rüdiger)*

at 500 deg. Cent. As a homogeneous system this gas is stable at even higher temperatures, but in the presence of catalysts it decomposes into nitrogen and hydrogen. The surface of the steel to be nitrided serves as a catalyst. The molecular ammonia is absorbed at active centres on the surface and decomposes. The atomic nitrogen so produced combines with the iron, and the hydrogen escapes into the gaseous phase. When the nitrogen content of the iron surface reaches a certain value the first-formed outside layer begins to decompose, the nitrogen simultaneously diffusing inwards so that equilibrium is established between the supply of atomic nitrogen, the diffusion of the nitrogen inwards and the production of molecular gas.

The factors of importance are: (1) the supply of atomic nitrogen, (2) the number and kind of active centres per unit surface, (3) the solubility of nitrogen in the steel to be nitrided and (4) the diffusion coefficient. Attempts to accelerate the process have been directed mainly to the modification of factors (1) and (2).

The method described by Bennek and Rüdiger aims at modifying the first of these. The piece to be nitrided is made the cathode of a glow discharge in ammonia at low pressure. The best results were obtained with a pressure of 0·75 mm to 1·5 mm in the discharge tube, the voltage of the discharge being 5000 volts



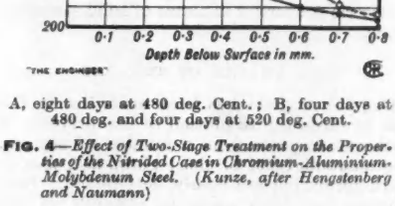
A, normal method; B, specimen "bonderised" fifteen minutes.

FIG. 3—*Effect of Phosphate Treatment on the Nitrided Case of Chromium-Aluminium Steel Produced in Twelve Hours and Ninety-Six Hours at 500 Deg. Cent. (Kunze)*

and the current 40 to 50 milliamps. The current at the same time heats the specimen by ion impact. The corners and edges of an irregular specimen were uniformly nitrided.

If the comparison is limited to short times, in which the increased supply of atomic nitrogen is the predominant factor, a greater depth and a greater hardness of case are obtained than by ordinary nitriding of the same duration; but at long times this advantage is lost, presumably on account of the overriding importance of the rate of diffusion.

Thus, the Vickers hardness of the case of a Nitralloy (aluminium-chromium-molybdenum) steel rose to over 1000 after six hours' treatment (Fig. 1), but for all times of treatment over twelve hours the advantage was with normal procedure. The thickness of the case was from 0·05 mm to 0·1 mm greater after these short periods of treatment, but reverts to



A, eight days at 480 deg. Cent.; B, four days at 480 deg. and four days at 520 deg. Cent.

FIG. 4—*Effect of Two-Stage Treatment on the Properties of the Nitrided Case in Chromium-Aluminium-Molybdenum Steel. (Kunze, after Hengstenberg and Naumann)*

the normal for longer times. The nitrogen absorption is much higher under glow discharge for the first few hours, as shown in Fig. 2, but it subsequently (in seven or eight hours) becomes about the same as in normal nitriding. The method produces in eight hours a case having maximum hardness of 1100, falling to 300 at a depth of 0·2 mm or 0·25 mm, but shows no advantage over normal nitriding if the treatment is prolonged.

While these observations are of scientific interest, it is unlikely that the process can have any immediate technical application on account of the complexity of the equipment required.

Kunze, in summing up past attempts at accelerating the nitriding of steel, refers to a number of physical and chemical means which have been proposed, such, for example, as Mahoux's suggestion to apply high-frequency oscillations to the specimen during nitriding, proposals to impose alternating stresses on the specimen, the numerous chemically applied coatings of the article to be nitrided and additions of various substance (*e.g.*, aniline, pyridine, &c.) to the ammonia atmosphere that have been recommended from time to time. He concluded that none of these had any useful effect in increasing the depth and hardness of the case with the exception of phosphate treatment (bonderising, &c.), an example of the effect of which is given in Fig. 3. His explanation is that the treatment somehow retards the decomposition of the iron nitride at the surface and so enables a higher gradient of nitrogen content to be maintained. Finally, he suggests that the two-stage process (an example of which he gives in Fig. 4) is capable of further development.

This process, which originated in the United States, was investigated in some detail by Dr. Brynmor Jones,[3] who criticised the proposal of Hengstenberg and Naumann to carry out the process at a temperature of 480 deg. Cent., followed by 500 deg. Cent (as shown in Fig. 4) on account of the long period of time occupied by the operations. His own recommendation was for two-stage nitriding at 500 deg. and 600 deg. Cent. By this means in a Nitralloy steel in a total time of sixteen hours a depth of case could be obtained equal to that produced in forty-eight hours by nitriding at 500 deg. Cent. only.

The two-stage method was regarded by Dr. Brynmor Jones[4] in 1937 as the only satisfactory method then existing of hastening the depth-hardening of the chromium-aluminium type of Nitralloy steel and the position seems to be the same to-day.

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[1] E. Kunze, *Archiv für das Eisenhüttenwesen*, 18 (September-October, 1944), 57–60.

[2] H. Bennek and O. Rüdiger, *Archiv für das Eisenhüttenwesen*, 18 (September-October, 1944), 61–67.

[3] B. Jones, Iron and Steel Institute, *Carnegie Scholarship Memoirs*, 23 (1934), 164.

[4] B. Jones, *Journ., Iron and Steel Inst.*, 136 (1937 II) 165.

Study of Age-Hardening by the Aid of the Electron Microscope

ONE of the more suitable metallurgical subjects for investigation by means of the electron microscope would seem to be the phenomenon of precipitation-hardening. So far little has been done in this direction and some photographs which have been published have shown particles of a size, shape and distribution which would not be expected from theory or from observation of particles which have grown to a size resolvable under the ordinary microscope.

The initial problem has been the development of suitable technique for the examination, by a transmitted electron beam, of the replica of an object generally viewed by reflected light. The oxide-film method has proved to be the most satisfactory means yet found for studying the microstructure of aluminium alloys with the electron microscope. This method has the advantage that the actual surface layer of the specimen is examined and not a plastic or silica replica.

The method of preparing the specimen and of removing the film has been developed by A. H. Geisler and F. Keller* who have applied it in the study of "Precipitation in Age-Hardened Aluminium Alloys." Even after the technique of obtaining electron photo-

* A. H. Geisler and F. Keller, American Institution of Mining and Metallurgical Engineers, 1946. Technical Publication No. 2108.

micrographs has been overcome the interpretation of results is still attended by difficulties. Most of the constituents of primary interest in studies of age-hardened aluminium alloys are oxidised and dissolved at a much faster rate than the solid solution of the matrix. Particles of a size less than the thickness of the film, and present on the polished surface, may be partially or completely dissolved, leaving depressions or holes in the film, and these thin places or gaps ultimately show as bright areas in the electron micrographs. Small particles below the original surface may be trapped with their oxidation products in the oxide film and thus appear as dark areas in the micrographs, while small particles at the interface of oxide film and metal may remain attached to the lower surface of the film unless released in the film-removal process.

A few quenched and aged high purity alloys and several commercial specimens were studied by means of the electron microscope, usually at magnifications of 20,000 to 30,000. Many of the micrographs showed small white spots which, as previously explained, were considered to be indicative of very small precipitated particles that had been oxidised and dissolved to leave gaps in the oxide film. The number of such spots was found to increase on prolonging the time of ageing.

A more comprehensive study was made with an aluminium alloy containing about 1·4 per cent of magnesium silicide, solution treated by heating for 15 hours at 1100 deg. Fah. and quenching in water, and then aged at various temperatures from atmospheric to 650 deg. Fah. for various times.

No precipitate could be detected with certainty in the alloy aged at atmospheric temperature (70 deg. Fah.) for two weeks at a magnification of 20,000. Enlargement to a magnification of 100,000 showed a mottled matrix, but this was not certainly indicative of precipitation.

Although ordinary microscopic examination at a magnification of 500 showed evidence of localised precipitation along slip planes in samples aged at 320 deg. and 420 deg. Fah., a definite general precipitation was observed only in the electron micrographs. The specimen aged at 420 deg. Fah. showed an array of white spots similar to those shown by other aluminium alloys, but this feature was not observed with specimens aged at lower temperatures or for shorter times. The precipitate causing age-hardening in this alloy, and also in the aluminium-magnesium silicide type of commercial alloys, is apparently much finer than in other alloys. In samples aged at 650 deg. Fah. for ten minutes or more, precipitated particles were attached to the oxide film and were clearly visible in the micrographs at a magnification of 8000 as flat plates in various orientations. After four hours' ageing a definite Widmannstätten pattern was formed. After ageing for twenty-four hours the particles were visible in ordinary micrographs at a magnification of 500. The specimens were over-aged by this treatment and the particles are much larger than those responsible for age hardening.

The form and dimensions of the particles are given in the accompanying table. In alloys aged at room temperature particles up to 0·03μ were observed. The particle size at maximum strength varied with the solute metal, for example, in aluminium-magnesium silicide alloys fully aged at 420 deg. Fah., the particles were only 0·01μ or less, whereas in the aluminium-silver alloy, fully aged at 320 deg. Fah., they were up to 0·5μ. The precipitated particles in the commercial Al-Mg-Si alloys aged at 350 deg. Fah. were smaller than those in the Al-Cu and Al-Mg-Zn alloys aged at elevated temperatures, but were comparable in size with the particles in these alloys aged at room temperature.

The expected plate-like nature of the precipitated particles was apparent only when their size exceeded 0·05μ in at least one dimension. The smallest particles (whether showing as bright spots or as opaque objects) appeared to be round, either because they were not adequately resolved or because their edges were attacked during the etching or the film removal treatment, though X-ray diffraction data have revealed that the precipitate is plate-like when the size is still less than 0·01μ.

Size of Precipitated Particles in Age-Hardened Aluminium Alloys

Alloy Composition, per cent	Ageing, temperature deg. Fah.	Size of Particles, microns
High Purity Alloys :—		
Silicon 1·23	420	0·01 to 0·02
	650	0·05 by 0·3 plates
Magnesium 0·95, Silicon 0·51	420	0·01 or less
	650	0·05 by 0·7 to 1·3 plates
Magnesium 9·10	310	0·03 to 0·1
Zinc 22·0	212	0·03 to 0·1
Silver 9·88	320	0·03 by 0·5 plates
Commercial Alloys :—		
Cu 4·4, Mn 0·8, Mg 0·4, Si 0·8	70	None observed
	340	0·03 to 0·04
Cu 4·5, Mn 0·6, Mg 1·5	70	0·01 to 0·03
	365	0·01 to 0·03 and 0·1 to 0·2, also 0·3 by 0·1 to 0·2 plates
Cu 4·0, Mg 0·5, Ni 2·0	340	0·01 by 0·04 to 0·08 plates
Cu 4·5, Mn 0·8, Si 0·8	340	0·01 to 0·03 and 0·05 to 0·3
Mg 1·3, Si 0·7, Cr 0·25	350	0·03 to 0·08
Mg 1·0, Si 0·6, Cu 0·25, Cr 0·25	70	Few, 0·02 and less
	350	0·02 and less
Mg 2·5, Cu 1·6, Mn 0·2, Zn 5·6 Cr 0·3	70	0·02 to 0·03
	250	0·01 to 0·03, 0·05 to 0·2

From a consideration of available data, Prof. Gensamer concluded that the strength of metallic solid solutions depends in a regular way on composition. It is a little amusing to note how, in drawing some of his straight lines to express this relation, the professor ignores certain data which he had provided specially for the lecture. This, however, was done deliberately and, as he says, because he had the courage of his convictions. The above conclusion relating to solid solutions, if applied over a limited range of composition, is not likely to be questioned, nor is the further conclusion that the effect of the dissolved elements is insignificant compared with the effect of finely dispersed particles. In aggregate structures the strength was found to depend in a very regular way on the mean spacing between the particles and not at all on their shape except in so far as this affects the mean spacing.

A further conclusion was that the strength of a material, in mass, was not sensitive to local variations in composition and structure, whereas its ductility was greatly influenced by local conditions. Ductility under tensile stress was studied in relation to four different tests on sheet metal: (*a*) narrow strip, (*b*) very wide strip, (*c*) unbalanced biaxial tension or elliptical bulge, and (*d*) balanced biaxial tension or spherical bulge. The distribution of strain was measured in each test.

Strain remote from the region of necking was much the same in all tests, but the local ductility near the fracture varied greatly. Few generalisations were possible about strain gradient in relation to either composition or structure. The whole matter was subjected to considerable mathematical analysis, but to conclude in Prof. Gensamer's own words :—

"Local ductility, unless very low, has little effect on energy absorption in structures; the distribution of deformation is apt to be of more consequence. Efforts to improve absorption of energy in structures by improving the local limiting deformation at the position of necking are liable to be disappointing. Improvement in deformation distribution by the modification of the plastic properties of substances should be more profitable when the intrinsic ductility is considerable. However, this should not be true at high strength levels where intrinsic ductility is low enough to be a more important factor. It is still important to try to improve the limiting local deformation prior to fracture in high strength materials, even though it is of less importance in our more ductile alloys."

If an attempt were made to express these conclusions in the simplest possible practical language, the result, it is thought, would be very much on the following lines :—

In the failure of structures local deformation is of primary importance. In design every precaution should be taken to avoid the possibility of steep strain gradients and severe local deformation. In manufacture, if the material to be used has good elongation and reduction of area, improvement must be sought by increasing its resistance to failure under localised stress, *i.e.*, by improving its behaviour in tests on notched specimens. In very hard materials this is still worth while, but is more difficult to achieve.

Therefore, it might further be added, it is important to avoid the use of unnecessarily hard materials. A reserve of ductility in the form of increased capacity to deform under localised stress, even if it involves a lower "factor of safety" calculated on the basis of strength, is a more effective safeguard against failure.

metallurgical applications of the electron microscope. With the development of improved technique and further experience in the interpretation of electron micrographs, the use of this instrument will, no doubt, be extended to the study of a variety of metallurgical problems involving "sub-microscopic" changes.

Strength and Ductility

THE twentieth Campbell Lecture, delivered before the American Society for Metals by Prof. Maxwell Gensamer, of the University of Pennsylvania, dealt with the two main aspects of the mechanical properties of metals, "Strength and Ductility." Strength was discussed in the sense of the resistance of a substance (*a*) to flow or (*b*) to fracture. By ductility is meant the amount of deformation which the material can undergo prior to fracture. There is an important distinction to be kept in mind between capacity for local and for general deformation; and, beside knowing the capacity of a metal for deformation locally, it is equally important to know how the deformation distributes itself.

IRON AND STEEL INSTITUTE.—The *Journal* of the Iron and Steel Institute will in future be issued monthly. Each month there will be sections devoted to papers submitted to the Institute, reports issued by the British Iron and Steel Research Association, activities of the newly-formed Engineers' Group and other items. The inclusion each month of a section on iron and steel works engineering should increase the value of the *Journal* to those who are primarily concerned with design and maintenance. In this section there will be printed papers read at meetings of the Group, the discussions on these papers, and authoritative descriptions of plant. The new arrangement started with the issue of January, 1947.

ZINC BULLETIN.—The Zinc Development Association (Lincoln House, Turl Street, Oxford), in conjunction with its associated organisations, is issuing quarterly a *Bulletin* dealing with the general aspects of the uses of zinc. The first number appeared in October and contained a short article on "Zinc Roll Cap Roofing." There was a brief reference also to the great advance made during the war in the production of zinc alloy die castings, as a result of which the British die casting industry expanded to about five times its pre-war capacity. Very great improvements were also made in the surface finishing and protective treatment of zinc alloys. It is of interest to learn that the Zinc Alloy Die Casters' Association has collected all available information on the coating of zinc alloy die castings by the electrodeposition of nickel, chromium, silver and other metals, into a book which will shortly be published, and which will be followed by a companion volume on the finishing of die castings by lacquering, enamelling and chemical treatments. These products, which have lent themselves so well to the mass production of war equipment, should have an even wider field of application in the future.

THE ENGINEER

MARCH 7, 1947

VOL. CLXXXIII No. 4754

Issues of February 21st and 28th not having appeared, the serial number of this issue, above, follows consecutively upon that of the issue of February 14th.

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

For Subscription Rates, see page 2 of Advertisements.

RESUMPTION OF PUBLICATION

NOW, after an interval of three weeks, THE ENGINEER again appears. It is surprising that it was ever thought worth while to ban its publication in company with all those other trade and technical journals whose publication was similarly suspended. For the loss in the dissemination of trade and technical news was, we believe, quite out of proportion with the very small saving of coal and electric power that was a consequence of the ban.

Much has been written in the daily Press about the value to the country of the comments on national affairs contained in a particular group of five weekly journals. It was, indeed, natural that the attention of the daily Press should especially be drawn to the effect of the ban on those journals. But, though we should be amongst the very last to deny their value, it was still, we think, invidious to select them alone for comment. Their publication should, indeed, never have been stopped. But neither should that of the trade and technical Press. Each of the weeklies and monthlies grouped under that latter title has, it is true, an appeal only to a limited section of the whole reading public. But their circulations, together, touch upon the activities of every professional, technical and business man or woman in the country. In their comments upon the effects of governmental and other public measures on their sectional interests, in discussing technical advances, trade practices and market changes, in bringing promptly before their readers technical articles and descriptions of new plants, new processes and new devices, in publicising the expressed views of eminent professional and business men and in conveying Governmental and other announcements of particular importance to their readers they perform a service which is not merely useful but essential to the efficient carrying out of the work of the country. Each of their issues is studied by their several readers, and the articles are read, as the correspondence columns of those journals often reveal, with a care and attention that is seldom devoted to articles in the daily Press. We hope that never again on any excuse will a wholesale ban upon the publication of such journals be experienced in this country.

We have received expressions of hope that as a result of the ban and the consequent economy in paper usage it may be possible to publish for the future somewhat larger issues of THE ENGINEER. Alas, the hope is in vain! All industries, we fear, will continue for months, if not years, ahead to be short of coal. The papermaking industry will be no exception. Indeed, it enjoys no priority in its demands on coal supplies and it was shut down during the crisis weeks. Unless there is some change in Government policy, less paper, not more, is likely to be available, and issues of THE ENGINEER will be smaller rather than larger than they were before. Our output, like that of industry at large, will be limited by the national shortage of coal.

THE ECONOMIC SURVEY AND THE COAL SHORTAGE

INEVITABLY, as a consequence of the time at which it was issued, the Government's "Economic Survey for 1947" was read with particular relation to the fuel emergency which closed down a large proportion of the industrial concerns of this country for a period extending in all areas affected to a fortnight and in London and the South-East to over three weeks. That emergency arose because coal was being used up substantially faster than it was being produced. Even had not unusually severe winter weather intervened to dislocate distribution, to increase the load upon electric power stations, and to produce the shock of a sudden check upon industrial activity it still seems certain that industrial production would have been severely hindered. For before spring could have arrived to relieve the pressure upon power plants and heating plants, stocks of coal at consuming works must have been so perilously reduced as to have administered widespread temporary stoppages upon industry with an effect in aggregate manhours of labour lost not very different, probably, from that forced upon it by the more sudden and more nearly complete cessation of work actually experienced. The productivity of industry in fact was beginning to be ruled not by its own enlarging capacity to manufacture but by the amount of fuel available to keep the machinery turning. The sharp sting of the crisis has now gone. Industry is at work again. But the aftermath of the crisis, the shortened fuel stocks at consuming works, the short-time working, the doubts as to the adequacy of coal allocations, the disorganisation of supplies of all kinds, the failure to maintain delivery dates, still remain to make it the more difficult to avert the possible but not inevitable consequences of that serious economic situation revealed in the Government's White Paper.

That White Paper refers in particular to the three main shortages, of coal, power, and men. The first seems to us, fundamentally, far the more important. For, by the use of more heat and power and of more machinery, engineers can and are rapidly finding the means for economising manpower. Indeed, if sufficient coal was available and if analogy with the years immediately following the 1914–18 war may be regarded as safe, productivity in this country per man year should be able to rise at the rate of 7 per cent or so per annum during the next few years as a result of their efforts. Nor is power so limited as power cuts might seem to indicate. It is maximum load capacity that is lacking and must remain lacking until new generating plant can be manufactured and installed. But by spreading the load—at the cost of working inconvenient and costly nightshifts in those establishments which can adapt their processes to an unusual routine, or by staggering working hours in some other way—and by persuading the public to economise its daytime use of electricity, it may prove possible to generate more units without exceeding maximum generating capacity or making it impossible adequately to maintain power station machinery. But more mechanisation and more generation of power both demand more coal. It is in the light of that fact that the Government's proposal in the White Paper that "we cannot afford to set a lower production target for 1947 than 200 million tons of coal, deep-mined and open-cast" must be examined. Would it not in reality be better to ask whether we dare, in our present economic circumstances, place the target so low? For, broadly, it seems nearly true that industrial productivity varies more or less directly with usage of heat and power and hence, in a country predominantly coal-using, on the amount of coal available. Any given percentage increase in industrial output must demand a comparable though not necessarily identical percentage increase in the demand for fuel. In 1946 the inland consumption of coal totalled 194 million tons. That consumption sufficed to sustain industrial exports rising from a level 16 per cent below the volume of 1938 in the first quarter of the year to a level 11 per cent above that of 1938 in the last quarter, and to provide for a home market production which, to judge from sample figures in the White Paper, made a comparable percentage advance, at, however, a lower level in relation to pre-war standards. By the last quarter of 1946 it seems fairly certain that industrial productivity was already being quite severely hindered by shortage of fuel. Yet the Government now proposes that a production of coal in 1947, only a very little more than 3 per cent above the 1946 consumption, shall suffice not only to build up stocks adequate for safety next winter but also to support such an industrial effort that exports shall reach by the end of the year a level 40 per cent above the 1938 value, an increase of about

25 per cent. As a corollary, it may be added that, as a direct consequence of the shortage of coal, so small an increase of the finished steel made available to industry as that from 8·1 million tons in 1946 to 9 million tons in 1947 is expected to suffice, although the annual rate of consumption of steel had already increased in the fourth quarter of 1946 to 9·2 million tons. The consequence of this restriction, as is admitted in the White Paper, must be discouragement of the further expansion of steel-using industries, just those industries, in fact, which manufacture power-producing plants and those very many other devices which by utilising power economize manpower and multiply the productivity of workers. It is probable, of course, that the limitation of coal output from the mines to 200 million tons is forced upon the Government. Manpower in the mines shows little signs as yet of rising, though output per man year shows a promising though not very large increase. Nor, in this year, 1947, could the drafting of trainee labour, British or foreign, into the mines produce very much immediate improvement in output. But if, in fact, no more coal than 200 million tons is produced in 1947, then, despite all economies, a level of exports 40 per cent above pre-war volume seems hardly likely to be reached unless production for the home market, insufficient though it is already, is reduced to a still lower level. And that depressing conclusion must be reached despite the fact that if the inflation that already threatens the country is to be avoided it is becoming very desirable that pent up purchasing power in the hands of the people should find some relief and that more goods, not less, should reach the home market.

Yet, though the economic position revealed by the White Paper is serious enough, it would be unreasonable to take too pessimistic a view of the future. This country's present troubles are short term ones, not long. The short term problem is that of rapidly expanding production to such an extent as to balance our international accounts. The long term one is that of maintaining exports at a sufficiently high level in the face of international competition to maintain a high standard of living in this country. Basically the fuel crisis that formed so sharp a commentary upon the words of the White Paper was brought about not by any failure to realise industrially that rapidly increasing rate of production that is so urgently needed, but by forcing that rate up too soon to a level too high in relation to the fuel stocks available. It may, indeed, be said that if industry is to be afflicted with a multiplicity of Government controls, it has at least the right to expect in return the co-ordination and regulation of supply against demand whose lack was so clearly the cause of the recent emergency. But it can hardly be claimed that there has been any lack of the necessary energy and drive in industry as a whole. The ability of British designers, inventors and manufacturers can hardly be doubted if their achievements in war are remembered. If the Coal Board exhibits vigour the output of coal from the mines can be made fully adequate within a few years to meet all demands. Power station plant adequate to meet the maximum demands of the early future is already under manufacture. Shortages of manpower can be overcome, when more fuel and more power is available, by the ingenuity of engineers in devising new machinery and production methods. Only the attitude of trades unions, shop stewards and the local leaders of the men during the critical short term period remains in doubt. In many works the endeavour to keep going despite failure of electricity supply brought managements and men more sympathetically together. Dare we hope that the crisis will have forced home to the men the reality of Britain's serious temporary economic situation and that until these immediate years to come—with all their need for maximum production despite shortages of fuel and raw materials and the frustrations of ministerial control—are over there will be less talk of shortened working hours and higher pay, fewer unofficial strikes, less insistence upon restrictive practices and a greater determination to get on with the job? Perhaps the report of the T.U.C. committee which is examining the whole situation revealed by the White Paper, will provide the answer. But the apparent failure of a meeting of representatives of engineering employers and trades unions last Monday to reach immediate agreement about the problems connected with night-shift working can hardly be regarded as a very happy augury.

SCIENCE AND THE GOVERNMENT

A FEW days before the embargo on the publication of weekly periodicals took effect, the constitution of the Advisory Council on Scientific Policy, adumbrated in the House of Commons by Mr. Herbert Morrison on January 29th, was announced, and was duly recorded in our issue of February 14th. It may be desirable to recall that this new Council takes the place of the Scientific Advisory Council that advised the Government on general or specific scientific questions during the war, that it will work in close association with the Defence Research Policy Committee, and that Sir Henry Tizzard, who is already Chairman of the last-named body, will be its Chairman also. The Council is composed of twelve scientists, representing various branches of knowledge, including engineering, which has the able support of Sir Claude Gibb and Sir Ewart Smith, both Members of Council of the Institution of Mechanical Engineers, whilst civil engineering is represented by Sir Reginald Stradling, Chief Scientific Adviser, Ministry of Works, and a Member of Council of the Institution of Civil Engineers.

The appointment of a body of this kind is a sign of the times. Heretofore, Governments at peace have relied upon the services of committees or commissions set up *ad hoc* to examine and report upon specific problems. Now they have a permanent panel of scientists to which they may refer—at any rate, for primary consideration—scientific questions in a wide field. What the precise duties of the new Council are to be has not been revealed. Probably no one knows, and no one will know until some occasion arises. Much might be said in support of an indefiniteness that leaves functions to be settled by circumstances. Nevertheless, notice should be taken of the significance of the title of the Council. It is not to be called upon to consider scientific problems, but to advise the Cabinet on Scientific Policy. In that respect it differs materially from its wartime predecessor, but possibly resembles the Defence Research Policy Committee with which it is to work hand in glove. Policy is a word of some latitude, and we may, for our part, confess that we should welcome a more specific definition. To take a case. Consider any great engineering problem of the day—let us say, the development of the gas turbine. Will it be the duty of the Council to advise the Government with regard to the industrial development of the turbine or merely to make recommendations on scientific research into that invention? Or, again, will the Council be asked in due course for its opinion on the practicability of the Severn barrage scheme—a scientific problem—or to express its view on the desirability of proceeding with the work as a matter of national policy? In both these cases we have on the one side the purely scientific policy, and, on the other, the policy of directing science for the public good. The development and utilisation of atomic energy presents a knotty problem of that order. Until we have some clearer indication of the kind and nature of the questions that are to be propounded to the new Council, it is impossible to say whether it will justify its existence or prove no more than an idle gesture of the Government's respect for Science.

The Council is composed of a diversity of men, all, with one exception, to a common denominator; they are all Fellows of the Royal Society. There is a pathologist, a botanist, an anatomist, a physicist, an agriculturalist, a few chemists, and three engineers, but, oddly enough, no one who represents electrical engineering, unless it be Sir Edward Appleton, who appears in another capacity. The one exception is Sir Alan Barlow, the secretary. Admittedly, all sciences are a row of pearls on one string; yet it may be wondered if any advice that so diverse a body can offer to the Government will be more than obvious and platitudinous. That remains to be seen, and not until Sir Alan Barlow has printed his first report of the proceedings of the Council shall we know if it is worth its salt or but one more device for wasting the time of busy men.

Obituary

ARTHUR R. T. WOODS

MANY engineers, especially those associated with the shipbuilding, marine engineering and refrigerating industries, will learn with deep regret of the death, on Thursday, February 20th, at his home, 7, Melina Place, St. John's Wood, London, N.W.8, of Mr. Arthur R. T. Woods. He was a former director and general manager of the Nelson Line, and later the Royal Mail Lines, Ltd., and a recognised authority on marine refrigeration. Arthur Robert Thomas Woods was born in Liverpool and was 87 years of age when he died. He was educated at Liverpool and at Louvain, and in 1875 he was apprenticed to Laird Brothers of Birkenhead. In 1880 he completed his apprenticeship and went to sea

for several years, gaining, in 1885, his First-class Board of Trade Ticket as marine engineer. He then went out to Brazil to join the Bahia Steam Navigation Company as a general engineer. In 1896 on his return to England, he joined the firm of H. and W. Nelson, Ltd., the managing owners of the Nelson Line. In that capacity his knowledge soon earned for him promotion, and he became successively superintendent, general manager and director of the firm. About 1899 he was responsible for the design of ten refrigerated ships, "Highland" class, for the carriage of meat from South America. Round about 1929 he took a leading part in the design and construction of five 14,000-ton motor ships of the "Highland Monarch" type, which were built and engined by Harland and Wolff at Belfast. In these ships provision was made to carry first and second-class passengers, and also emigrants, in comfortable quarters, between this country and South America. For the carrying of the cargoes of frozen and chilled meat in these ships, Woods utilised for the first time four-cylinder single-acting horizontal oil engines of the Crossley-Premier type, direct coupled to ammonia compressors. Later on, when the Nelson Line was absorbed by the Royal Mail Lines, Ltd., Mr. Woods, who had been a director of the Nelson Steam Navigation Company, was made a director of Royal Mail Lines, Ltd., a position he occupied until he retired from active service in 1933.

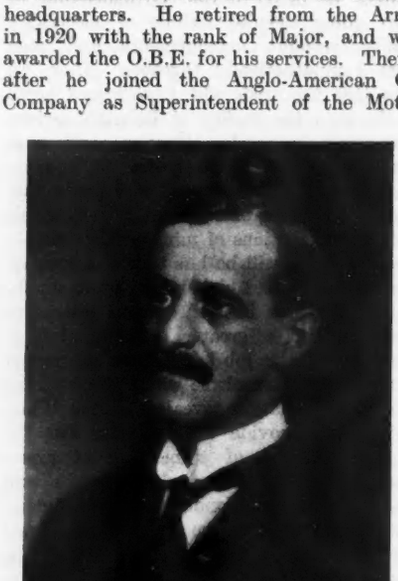
He was an early member of the Institute of Marine Engineers and became a Vice-President He was also a member of the Institution of Mechanical Engineers and the Institution of Naval Architects, and a founder member of the British Association of Refrigeration, which later became the Institute of Refrigeration; he was a Vice-President and an honorary member of the latter body. He was a Past-President of the Liverpool Engineering Society and a Fellow of the Society of Consulting Marine Engineers and Ship Surveyors. Mr. Woods was also keenly interested in fire prevention and served on the committee appointed by the Chamber of Shipping to investigate means for the prevention of fires aboard ships. He was a Liveryman of the Worshipful Company of Shipwrights and was a Past Prime Warden of the Company. Among many friends, he will long be remembered as one who did much for the British mercantile marine and the improved transport by sea of refrigerated produce.

EUGENE GUY EUSTON BEAUMONT

It is with very great regret that we have to record that Major Guy Beaumont died suddenly from heart failure, on February 19th. He was in his seventieth year.

Guy Beaumont was the second son of the late W. Worby Beaumont, who at one time was for ten years assistant to the editor of this journal, then the late Vaughan Pendred, and who later set up a consulting practice, specialising in automobile engineering. Guy was educated privately. He served his apprenticeship with Davey, Paxman and Company, and subsequently remained with that firm until 1903 as chief assistant to the works manager. At that time the company was engaged on the production of the Pasche engine, which competed with the Willans and the Bellis engines for central station work. Guy became mainly interested in steam power plant, but in 1903 he joined his father as principal assistant in his consulting practice and soon became immersed in motor vehicle and road transport subjects. During this period of his career he took an active part in the production of his father's "Motor Vehicles and Motors," the first volume of which was published in 1900, and the second in 1906. This work to-day constitutes a valuable record of the early days of automobile engineering.

On the outbreak of war in 1914, Guy joined the Motor Transport Section of the Army Service Corps and was appointed an administrative staff officer at the London headquarters. He retired from the Army in 1920 with the rank of Major, and was awarded the O.B.E. for his services. Thereafter he joined the Anglo-American Oil Company as Superintendent of the Motor



EUGENE GUY EUSTON BEAUMONT

Transport Department. In that capacity he had under his control the largest fleet of motor vehicles then in this country. On the death of his father, in 1929, he retired from the service of the Oil Company and set up for himself as a consulting engineer engaging principally in automobile and road transport work. Like his father, he built up a considerable reputation in the Law Courts as an expert witness and by a curious coincidence it was at the Law Courts while giving evidence in a private case that he suddenly collapsed and died. He inherited his father's ability as a mechanic and took great delight and much pains in constructing models to explain technical points to judges and juries.

He was a member of the Institutions of Civil, Mechanical and Automobile Engineers, of the Institute of Transport and of the Association of Consulting Engineers. He joined the Institution of Automobile Engineers in 1909, was appointed to its Council in 1924, became a vice-president in 1926, and was elected to the Presidential Chair in 1927. He acted as chairman of the Institution's committee which, in 1937, published the "Memorandum of Professional Rules and Practice of Members Practising as Consulting Engineers."

Guy Beaumont's health was never robust, but his willpower and determination triumphed over his physical weaknesses. His cheerful energy encouraged and inspired those who were brought into contact with him. His office was close to our own and we saw much of him during the recent war, when he was in charge of the fire-watching organisation of our area. It was no light task for a man of his age and frail constitution, but he performed it with great assiduity. The post was not a sinecure. Incendiaries and flying bombs did their best to wreck Essex Street. His own office building and ours suffered damage and narrowly escaped complete destruction on at least two occasions.

In common with many others we shall miss Guy Beaumont's friendship. In many respects his character and abilities duplicated those of his father and there survived in him a feeling for this journal which, we were always pleased to believe, amounted to affectionate personal interest. We never hesitated to seek his advice when we required it and we are glad to recall that more than once he sought, with the freedom of a friend, such help as we could give him on technical subjects.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

WHERE DO WE GO FROM HERE?

Sir,—The correspondence arising from Mr. Rice's article, "Where Do We Go from Here," suggests that neither the urgency nor the complexity of the current problem of industrial morale is yet fully appreciated in this country. It is, indeed, clear that all your correspondents, except one, make a number of unrecognised assumptions about what we usually call human nature, and that part of the difficulty in considering problems of people at work derives from the effort needed to find the essential common basis on which to conduct the discussion.

In our daily lives everyone of us is of necessity a psychologist, but the opportunity comes only to a few to try to clarify the complex psychological events of everyday life as a means of diminishing human misery and of improving our prospects of finding liberty, life and happiness.

It is an over-simplification of a most dangerous kind to suggest that present problems of industrial organisation and production—and, indeed, economic problems in general—are no more than the results of two world wars and their even more disastrous aftermaths. These events have indeed occurred; but it is difficult to avoid two important conclusions: that the events are in themselves symptoms, and not causes of, more fundamental difficulties in our present world situation; and that these difficulties relate to the economic and social revolution through which the whole world is now passing. For this reason it is important that discussions of industrial problems should not be restricted to irritable and fruitless obsession with attempts to make past industrial practice produce the result which it did in the nineteenth century. So long as the exploitation of natural and technological resources of the more advanced industrial countries was completely consistent with an improvement in the welfare of mankind in general, and so long as there were insatiable markets for consumer goods in backward parts of the world, the answer to the question "production for what?" was both clear and acceptable. It can hardly be said, however, that the overall economic and industrial situation has not undergone a fundamental change. Technological development has taken, and will no doubt continue to take, enormous strides, but it is a widespread view that many

of our present world problems are related to what is most commonly and most easily thought of as the disproportion between the adaptability of the machine and the apparent intransigence of man.

The main purpose of this letter is to suggest that considerable evidence exists to throw doubt on the view that man, or human nature, is unchangeable; to suggest further that it is useless to deplore man's sinfulness and to hope vainly for a change of heart; and finally, to suggest that, quite apart from the findings of such special observers as cultural anthropologists, evidence exists that man is capable of adapting himself to the most diverse situations, provided certain basic psychological needs of the individual can be met. In the industrial field both general experience and special investigations point to the significance and the variability of the human factor in production. Few industrialists would deny the impossibility of forecasting the relative production of two factories making the same kind of product with approximately the same technical resources; and most people are indeed aware of the wide variation in productive output between industrial groups possessing similar technical facilities. Equally, it would be difficult to prove any direct correlation between good physical conditions and high output; there are many industrial groups in which physical conditions are outstandingly good, but in which production is known to be no better than in others in which conditions approximate to those of an industrial slum. And finally, consideration of the result achieved by time and motion studies, piece rates and bonus systems can be said to point to only one possible conclusion: that it is extremely difficult to show any consistent relationship between industrial efficiency and what are described as "financial incentives." The conclusion of most studies, therefore, is that there are many mysterious factors which seem to affect production—and to some, perhaps, the most mysterious factor of all is that available knowledge—and the available experimental findings—seem so far to have been neglected by most of those who are responsible for industrial efficiency.

There is a growing realisation to-day of the dangers and problems which have resulted and are still resulting from the disproportionate effort spent on the relatively simple field of physical science, as against the more complex field of the social scientist who is concerned with human affairs. For many thousands of years men have been exhorted to live together in peace, to strive for the common good, to help their neighbours; while, at the same time, their strongest efforts have been directed to the destruction of each other either by war or economic competition. At last, some attempts, however ill-equipped and ill-supported, are being made to study scientifically why man behaves as he does and how that behaviour can be changed. Here it may be sufficient to mention the results of two experiments. In a particular industrial plant the development of improved co-operation—not by exhortation, which possesses more vices than virtues, but by giving full opportunity for participation—resulted in an increase in production which was shown to be beyond the maximum possible computed by the production engineers. In the second it was shown, beyond any possibility of doubt, that neither exhortation nor a rational intellectual approach was of the slightest practical value in diminishing prejudice, but that group co-operative effort could overcome both strong prejudice and ingrained habit.

These are some of the reasons why it is important to pause and to think carefully before arriving at the pessimistic conclusion that human nature is weak, evil and probably unchangeable. It can be said with some assurance that had anything like the time, money and effort, which has been so fruitfully spent on the development of machines, been duplicated by an equivalent effort in studying the psychological and social problems of mankind—particularly in our industrial communities—that some, at least, of the problems of the present day would not exist. It is true that some development in social science is beginning; but without waiting for the results of time-consuming and expensive experimentation, it is at least possible for all those concerned with the present problems of industry to ask themselves whether they spend as much time and effort and probe as deeply and with as much patience, when they are trying to understand the problems of men, as they do when dealing with those of machines and materials. It may be encouraging to note that among the many differences between men and machines there is at least one of great importance; merely to spend time in the company of a machine considering what is wrong with it, does not affect its performance, but to devote time and attention to considering and discussing the problems of our relations with each other can often produce a fundamental change in the degree of co-operation, and in the results of our common endeavours.

JOHN D. SUTHERLAND.

London, W.1, February 8th.

INSTITUTION OF CIVIL ENGINEERS

SIR,—You have been good enough to give publicity ever since 1944 to the question of reform of the Institution of Civil Engineers in respect of the election of the Council and I hope that in due course you will again be kind enough to publish this appeal to all corporate members of that Institution. This should be the final letter on the subject for the Council has called a Special General Meeting for June 24th next, at which the matter must be settled one way or another.

This meeting will be preceded by a postal vote and will, therefore, be unable to affect matters much, for the decision will depend on the votes of the thousands of members all over the world, and not on the two or three hundred at the meeting. It therefore behoves every member to read and digest the circular and pamphlet sent out by the Council before voting. The pamphlet gives a full and fair report of the speeches at the Special General Meeting on October 31st, while the circular expresses some opinions of the Council. In so far as these opinions have been answered in debate, I propose to leave what has been said on both sides to stand, but there are three points in the Council's circular which are fresh and need an answer.

Firstly, the insinuation is made that the whole reform agitation is engineered by a small local body of people in London. This does not cover the facts, for the signatories to the two requisitions for Special General Meetings included a high proportion of members from the provinces, while correspondents from far afield in the Dominions have expressed sympathy with the proposed reforms.

Secondly, the Council slurs over its refusal to allow special representation to associate members by saying there is nothing to prevent associate members becoming candidates for the Council if they can get the necessary support under the Council's scheme. This burkes the issue. What is proposed in Resolution A is that associate members should have a certain number of seats reserved for them as of right.

Thirdly, the Council condemns as unworkable (the procedure proposed in Resolution A) for ascertaining the opinion of members. No scheme can be simple whose object is to obtain the informed opinion on controversial affairs of thousands of men scattered all over the world, but the scheme proposed is certainly not unworkable, and any necessary amendment of the routine for such an operation can be made "in Committee" as it were. An alleged need for variation in routine is no reason for rejecting a whole scheme of reform.

The point at issue is simple. Those corporate members who wish to be able to choose and elect their Members of Council in a free and representative manner will vote for Resolution A.

F. NEWHOUSE.

Twickenham, February 25th.

The Electricity Cuts

As it has been impossible to publish THE ENGINEER since February 14th, there has been no opportunity until now to place on record the salient facts about the electricity cuts which were imposed upon and dislocated a large proportion of British industry between February 10th and March 3rd.

The first intimation of those cuts was made by the Minister of Fuel and Power, Mr. Shinwell, in the House of Commons on Friday afternoon, February 7th. He drew attention to the increased consumption of coal at electricity generating stations—it was 731,100 tons in that particular week—to the wearing down of stocks, and to difficulties in coal production and transport which were being accentuated by severe weather conditions. To avoid a complete breakdown of the grid, it was decided, therefore, that no electricity should be supplied to industrial consumers in the London, South-Eastern, Midland and North-Western Districts, and that domestic consumers in those areas could use electricity only in certain hours. Electricity supplies to specified essential services were to be maintained. This decision became effective from Monday, February 10th, Mr. Shinwell expressing the hope that "in the course of a week or so" it would be possible to recover from the present position and to restore the full electricity supply to industry and to the domestic consumer.

On Monday, February 10th, the Prime Minister, Mr. Attlee, made a broadcast statement giving facts about coal production, transport and consumption, and stressing that the electricity situation was most critical in London, the South-East, the Midlands, and the North-West. On Wednesday, February 12th, it was announced that the Prime Minister had set up a joint committee of Ministers and representatives of the Coal Board, the Central Electricity Board and the Railway Executive Committee to take decisions and co-ordinate action from day to day. It was also announced that restrictions on the consumption of electricity for domestic purposes would be applied to the whole of England, Scotland and Wales from the morning of February 13th, and that electricity supply undertakings were authorised to reduce their voltage by 5 per cent, both during the day and night, to save power.

At the end of the first week of the cuts, coal stocks at the power stations had improved and equalled 10¾ days' supply, and on February 19th the Prime Minister was able to state that a resumption of the use of power by industry in the Midlands area could be made on Monday, February 24th. He stressed that this resumption depended on fully maintaining the restrictions on the use of electricity by domestic and non-industrial consumers, and said that he was not in a position to make a statement about resumption of power supplies to industry in the other two affected areas.

On February 24th, another statement by the Prime Minister indicated that the average level of coal stocks at power stations in the North-West area had reached about 15½ days' consumption, and that it was proposed to allow a resumption of the use of power by industry in that area on Monday, March 3rd. By the end of last week, the average level of coal stocks at power stations throughout the country had reached 16½ days' consumption, and on Saturday the Prime Minister announced that industry in the London and South-Eastern area would also be permitted to resume the use of electricity on Monday, March 3rd.

Locomotive Power at Speed

THE INSTITUTION OF MECHANICAL ENGINEERS

No. I

A GENERAL meeting was held at the Institution on Friday, February 21, 1947. The following paper, an abstract of which is begun on page 202, was read and discussed, "The Development of Locomotive Power at Speed," by E. L. Diamond.

Discussion

Mr. R. C. Bond, in opening the discussion, said that, while the Rankine cycle could never be entirely replaced as a basic standard of comparison, it was not altogether convenient for a locomotive, which must work at varying degrees of cut-off and usually with some losses due to incomplete expansion. There could be no doubt that a cycle such as that of the author or the Lawford Fry cycle had considerable advantages from the point of view of the investigation which the author had carried out; but personally, he could not help feeling that as the author had constructed his cycle it was neither a theoretical cycle in the full sense of the term nor did it represent the best which could be obtained from a given cylinder working under given conditions, because the back pressure assumed was not atmospheric, and the relationship between cut-off and compression had been chosen in a purely arbitrary manner. He felt that if the author had used the method put forward by Da Costa in a paper to the Institution of Locomotive Engineers* in 1939 he would have achieved a more satisfactory standard with which to compare the results of his locomotives in service.

Had the author done that, it was probable that the steam consumptions calculated in Table I of the paper would not have been greater than was in fact shown to be possible in the tests with the German State Railways' locomotives. Any standard of comparison ought to be something which one could begin to reach but never exceed, but from Table I it would be seen that the actual steam consumptions were lower than those given by the author's cycle.

The author had rightly drawn attention to the importance of clearance, but had he ensured the most efficient relationship between cut-off and compression he would probably have found that clearance would not have quite so exaggerated an effect as Figs. 1, 2 and 6 seemed to show.

He was very glad to see that the author emphasised the futility of increasing boiler pressures unless the cylinders and valve gear were designed to take full advantage of that increased pressure. He thought that that had been generally recognised in the reduction in the factor of adhesion from about 5 with 20-ton axle loads twenty years ago to 3·75 to-day with 22½-ton axle loads. That went to show that with cylinder capacity as it was to-day it was possible to take full advantage of the expansive properties of the steam and the available heat drop.

The progress to which the author had drawn attention was very well shown by the comparison of the indicator diagrams in the paper. It would be seen there how very different the rebuilt "Royal Scot" locomotive was from the earlier example referred to. There was one point to be borne in mind, however, in looking at those diagrams. The basic diagram was representative of work done by a very much greater weight of steam than was actually able to force its way into the cylinder. He would like to suggest that the author's diagrams would be improved by the addition of another expansion line: that representing the theoretical expansion of that weight of steam which was estimated to be actually in the cylinder.

He would like the author to indicate the steam chest pressure on those diagrams, so that it was possible to assess how much of the loss of pressure on admission was due to restriction through the steam ports and how much to restriction through the regulator valve, superheater elements and the steam circuit generally.

The author, in his introduction, recognised the importance of the steaming capacity of the boiler as a final criterion of the ultimate power output of the locomotive. It must always be remembered that essentially a locomotive consisted of three power-producing elements: the boiler, the engine and the connecting link between the two—the smokebox, chimney and blast pipe. The efficiency of the last determined very largely the actual performance of the other two; and, while it was most important to utilise the steam efficiently, a good steaming boiler was even more important. Perhaps that was the reason why in the past, and even to-day, a single curve of mean effective pressure in relation to speed, the limitations to which at low speeds were cylinder dimensions and adhesion weight, and at higher speeds boiler capacity, remained sufficient for most purposes of design and load determination.

Mr. E. W. Marten referred to the author's statement that "The main assumption in making these calculations relates to the point of compression," and drew attention to the fact that in Fig. 1 there was shown a compression at 50 per cent. cut-off which, might be regarded as a very low typical example for a Walschaerts gear. He thought that a higher compression there would be necessary from the point of view of fuel economy in operation, and that would necessarily bring the curves on that chart slightly lower in value for the different cut-offs.

The curves which were shown for valve openings in Fig. 13 were significant, because those were either Walschaerts gear proper with piston valves or else poppet valves operated by Walschaerts gear. That fact should be appreciated, because the curves were intended to demonstrate the cross-sectional area which could be obtained with a poppet valve. If one were operating a poppet valve with a truly cam-operated gearbox, one would find that those curves would give a much better opening with shorter cut-offs than was the case generally with the characteristics shown. That was of importance, because the whole object of the investigation was to demonstrate what had been done in the intervening years since the days of Dalby in improving the efficiency of the locomotive, and it all turned, as Mr. Bond remarked, on the yardstick of the mean effective pressure, and the consequence was that the best showing in the paper was with the poppet valve.

Mr. E. S. Cox said that the author had made some reference to the converted "Royal Scot" class of 4-6-0 locomotives on the L.M.S. Railway. He would incorporate some supplementary particulars of that locomotive in his written contribution, and he then showed two slides, the first of which illustrated in rather a different way the fact that locomotive performance generally had improved very greatly over the last twenty-five years.

Consideration of Boiler Capacity

He did not think that it was possible to leave out consideration of the boiler in evaluating locomotive performance at speed. Secondly, he thought that it was very desirable to make sure that the points used in obtaining any such curves as those in Fig. 11 of the paper were obtained from diagrams taken at the maximum power output, at the point before the boiler imposed its limit of capacity; if one took them from indicator diagrams taken from further down, one might not get a representative shape of curve at the higher speeds. Those points, of course, could be much better examined when the stationary testing plant was available, and the author's work would be of the utmost value in helping and guiding investigations when the Rugby testing station became available.

Mr. E. C. Poulteney said he wished to draw attention to the fact that it was necessary to take into consideration the boiler capacity. A sketch illustrating that point showed the mean effective pressure lines plotted against speed, and the point which he wished to make was that unless the boiler capacity was known it was not possible to sketch in the ultimate tractive effort lines, because one did not know, unless one knew what steam supply was available, what speed would be obtained for a certain cut-off. With a very large boiler it was possible to run at greater speed at a longer cut-off, so obtaining a second line shown on the diagram, which corresponded to the higher indicated horsepower.

Professor G. V. Lomonossoff said that the author's condensed but comprehensive paper covered four subjects, each of which could be developed into a volume. The first was the question of the ideal cycle for the locomotive. In this country the Rankine cycle was still in common use, although it was absolutely unreliable in reciprocating engines. In that respect Zeuner's cycle was better, but it ignored the influence of the clearance and compression. Twenty years ago, at a meeting of the Institution, Lawford Fry proposed his "locomotive cycle," but on that occasion Mr. Diamond justly pointed out that it was too elastic and indefinite. Mr. Diamond now proposed his own cycle, which personally he thought was the most practicable.

The second and most important subject dealt with in the paper was the recent improvement of locomotive steam distribution. The third subject, to which most of the author's diagrams referred, was the phenomenon of distortion of indicator diagrams due to turbulence in the steam flow, which increased with the speed.

In accordance with all tests, except those of Desdouits and Doyen, the tractive effort F fell, when the speed increased, according to the parabolic law $F=F_o-C\,V+C\,V^2\ldots P$. But he agreed that the author's law, $F=F_o-\sqrt{V/k}\ldots A$, was not only simpler, but at speeds over 120 r.p.m. agreed with the results of his (the speaker's) tests better than parabola P. As to low speeds, the Doyen curve seemed the most probable.

What was most important, however, was the fact that in order to establish and compare all these relations each of them should correspond to the same conditions. As he understood it, however, some of the author's curves related to variable openings of the regulator. That greatly diminished their

* "The Indicator Diagram and the Efficiency of the Non-Condensing Simple Expansion Steam Locomotive." *Journal*, I. Loco. E., No. 149.

practical significance; the opening of the regulator considerably changed the values of b, c and k, and the full opening was not always the optimum one.

The fourth subject of the paper was the universal power formulæ (locomotive ratios) such as those of Frank, Cole, Kiesel and Lipetz.

Mr. F. C. Johansen said that, with regard to the first factor, exemplified by Figs. 1 to 4, it was an instructive exercise to consider how the physical agents involved led to the conclusion that the effect of a small change in clearance volume was greater for small than for large percentage clearance space, greater for early than for late cut-off and greater for high than for low steam pressure. The trends of design towards small clearance, early cut-off and higher steam pressure therefore enhanced the critical effects of clearance and pointed to the care with which it needed to be considered in future work.

Effect of Speed on Mean Effective Pressure

With regard to the general effect of speed on mean effective pressure, he would like to hear some discussion of the author's basic formula on the penultimate page of the paper. A perhaps minor feature of the construction of that formula was that k had the same dimensions as $\sqrt{N}$—namely (Time)$^{-1}$—and was therefore hardly to be described as a coefficient. But when, on the next page, the author said that k (having the dimension T^{-1}) was an index of power-weight ratio which had the dimensions of speed, one felt that the situation was getting a little out of hand. The interesting point, however, was that if k, or some equivalent quantity, was in fact an index of power/weight, and should therefore have the dimensions of speed, then the formula could be made rational by reconstructing it to fit the experimental points with an appropriate function of, say, speed of travel or piston speed in place of $\sqrt{N}$.

There followed the further point, which was arguable on purely physical grounds, that the reason why the power of an engine fell off at high speed was not primarily the frequency at which the steam entered and left the cylinder, although admittedly some of the power inherently available in the steam was used in overcoming its inertia, but rather the fact that the steam failed, for various reasons, to enter the cylinder fast enough to keep pace with the rapidly moving piston without falling in pressure. Perhaps the most logical base, on physical grounds, was the speed of flow of the steam, which depended on the rate of change of cylinder volume as the piston moved.

It was clear that, for an engine of any given dimensions and geometry, r.p.m. was a measure of both piston speed and rate of change of cylinder volume. The author, however, allocated representative values of k to various types of engine, and much of the practical utility of his formula resided in its use for comparing performances of different locomotives of the same type and for inferring the power-speed characteristics of projected locomotives from the known characteristics of existing ones having the same sort of expansion and valve gear. Within a single type, so defined, considerable variations in size and proportions were practicable, and the power-speed characteristics would, in general, differ according to the speed which was used as a base.

Apart, therefore, from the question of whether r.p.m. or some linear speed was the more rational basis for comparing high-speed performance, and, indeed, on purely physical grounds, the number of cylinders in which power was being developed at high speed seemed to be a factor of sufficient importance to warrant account being taken of it in the assignment of values of k to different engine types, whether the basis of comparison was r.p.m. or some other measure of speed.

(To be continued)

C.E.B. Winter Operating Conditions

A RECENT statement by the Central Electricity Board provides an informative picture of the operating conditions governing the electricity supply during the present winter. These conditions are clearly brought out in the accompanying load curves which indicate the situation on Thursday, January 30, 1947, when the highest demand so far recorded on the National Grid System occurred—10,920 MW compared with the estimated maximum demand of 9,210 MW for the winter of 1945/6.

Curve A shows the load that was actually met by the available plant capacity on January 30. Curve B shows the load that would have developed if it had been possible to maintain the frequency at 50 cycles per second. The cross-hatched portion between curves A and B therefore represents the load relief obtained by lowering the frequency. Curve C shows the estimated demand that would have been supplied in the absence of any necessity for load shedding; the portion between curves B and C represents the relief obtained by load shedding. During the morning peak the sustained output from the available generating capacity was 9,092 MW. The difference between the preliminary figure of 10,920 MW for the maximum demand and the output of 9,092 MW is accounted for by load relief; 295 MW of load reduction was obtained by allowing the frequency to fall from 50 to 48·4 cycles per second, and a further reduction of 1,533 MW was obtained by shedding load in amounts varying from 25 per cent to 10 per cent in the various Board areas.

An interesting comparison of the plant conditions on certain specified days is given in the following table. For the purpose of this comparison, the days selected were January 29, 1947, when the highest generation output was recorded, January 30, 1947, when the highest demand was made on the Board system, and January 21, 1946, which was the day of maximum demand for the winter of 1945/6.

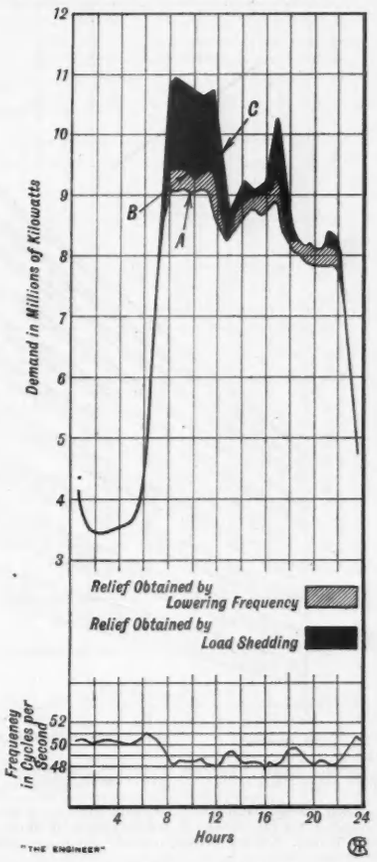
	Jan. 29, 1947 MW.*	Jan. 30, 1947 MW.*	Jan. 21, 1946 MW.
Rated maximum output capacity ...	10,666	10,666	10,527
Output capacity not available due to to :			
Breakdown ...	852	914	652
Overhaul	207	204	439
Unsuitable Fuel...	347	374	237
Other causes ...	99	150	352
Circuit restrictions	9	9	16
Total reductions ...	1,514	1,651	1,696
Rated capacity of available plant ...	9,152	9,015	8,831
Load actually met...	9,261	9,092	8,906

* Preliminary figures only.

The reasons for the loss of availability given in the foregoing table are illuminating. It will be noted that since January 21, 1946, the loss of capacity due to plant breakdown has increased by about 50 per cent, which indicates that the enforced use of over-age plant is levying an increasing toll. At the same time, to have reduced by more than 50 per cent the loss of capacity due to overhaul and other causes is no mean achievement. It will be observed that the loss due to unsuitable fuel has increased by more than 50 per cent in the past twelve months.

Operating conditions throughout the past three months have been exceptionally severe; generation has been maintained at a level higher than 9,000 MW since the beginning of December without any respite for generating plant, approximately 15 per cent of which is more than 20 years old.

The difficulties of carrying out load shedding up to values as high as 25 per cent are extreme and call for the greatest care in dealing with the heavy transfers of energy which are introduced on the Grid network. Difficulties arise not only during the peak load periods between 8 a.m. and 6 p.m. when there is insufficient plant to meet the total load in the country, but also later in the evenings and on Sundays when generation has on occasion to be restricted in order to avoid dangerous over-



CENTRAL ELECTRICITY BOARD—NATIONAL LOAD CURVE

loading of transmission lines. Sustained operation at low frequency for long periods has made it impossible to carry out the necessary clock correction during the night period and in present circumstances correction of synchronous electric clocks has had to be discarded. Load shedding has had to be a feature of normal daily operation as will be seen from the following table; a maximum was reached on January 30, when the load shed was 1,533 MW.

	Number of days on which load was shed
October, 1946	6
November, 1946	9
December, 1946	19
January, 1947	19

As the proportion of time-expired plant increases so the problems involved in plant overhaul become more difficult. To some extent the winter stringency can be relieved by deferring overhauls until the summer months wherever possible. With the existing plant shortage, however, the available margin is likely to be so small that the sudden incidence of inclement weather may necessitate load shedding during the summer.

The Development of Locomotive Power at Speed*

By E. L. DIAMOND, M.Sc. (Eng.), A.M.I. Mech. E.†

Introduction

Steam locomotive design may appear to have remained static for the last fifty years, as compared with the technical developments of stationary steam plants and other forms of prime mover. It is true that there have been no fundamental changes in the construction or the working principle of the steam locomotive apart from the use of higher steam temperatures. Yet the power capacity of the average locomotive of 1900 was a mere fraction of that of the best contemporary designs for the same unit cylinder volume at the speed of running prevailing in 1939. If the performance of locomotives over the range of speed 250–400 r.p.m. is examined, it may justly be claimed that progress has been commensurate with that of other established types of engine. If it had not been so, it is almost certain that the non-condensing reciprocating engine would not have maintained its pre-eminence for railway service.

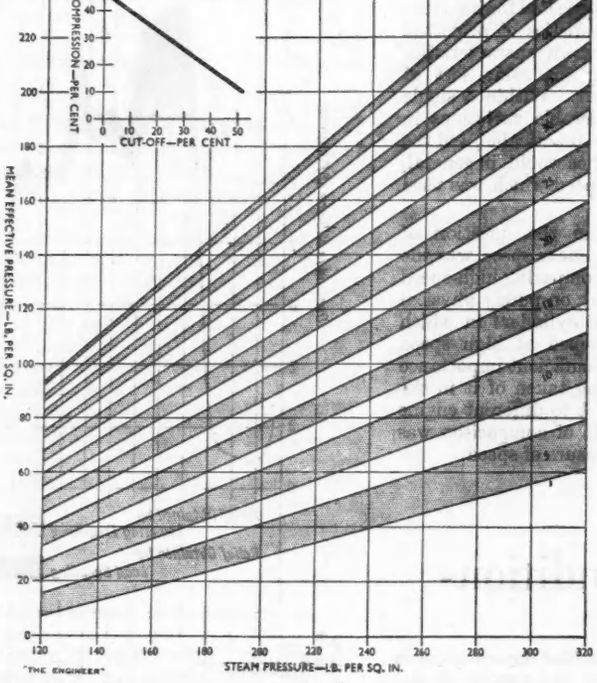
It has to be admitted that the spectacular developments of locomotive performance in recent years are not entirely the result of devices or principles unknown at the beginning of the century. The performance of a locomotive in practice is, however, so dependent on the steam-producing capacity of the boiler that there grew up a habit of basing any study of its power on the evaporative capacity of the boiler. Some years ago the author made a survey[1] of the various methods that have been used for calculating and measuring locomotive horsepower, and it will be found that almost all the early formulæ were based on the boiler, notably those of Frank (1887) and Goss (1901), which expressed the power of a locomotive as a function of the heating surface. It has generally been a fundamental assumption that the power of a locomotive is limited by its evaporative capacity, but whilst this is obviously true in a broad theoretical sense, it has not always been true in practice of large-wheeled locomotives burning good coal. The author has had experience of such locomotives of older design which, when in good running order, would steam freely at any speed in full gear and at full regulator opening, the power being limited only by the capacity of the engine to take steam at speed and to exhaust it without excessive rejection of energy.

General appreciation of the fact that the remarkable capacity of the locomotive boiler to generate steam surpassed the ability of the engine to make use of the steam was also delayed by the complications arising from the absence of a normal running condition in locomotive operation. In stationary steam plant practice the engines or turbines are designed to run at a specified speed and ratio of expansion, and no doubt has existed that the logical procedure is to fix the capacity of the plant as the power of the turbines at the designed operating conditions, the designer being responsible for seeing that sufficient boiler capacity is provided to supply the steam required. There are no such fixed design operating conditions in the case of a locomotive. Moreover, the fact that before the advent of the stationary test plant, locomotive tests were generally carried out under fluctuating conditions made it difficult to determine the effect of speed on the power and efficiency of the engine.

The introduction of the test plant, notably that of the Pennsylvania Railroad at Altoona, and of constant-speed methods of road testing, focused attention on the great variation in locomotive performance in the higher speed range and gave a powerful impetus to the improvements in the design of valve gears and steam circuit which have produced such a transformation of the high-speed performance of the locomotive.

The mean effective pressure in a locomotive cylinder can, of course, be readily calculated for any given steam conditions, valve events and clearance, assuming only the back pressure during exhaust. The calculated mean effective pressure is independent of the speed, so that the indicated horsepower derived from it would be directly proportional to the speed. In practice the mean effective pressure falls as the speed increases, and it is this increasing deviation from the ideal which may limit the power of the locomotive just as effectively as the capacity of the boiler. The late Professor Dalby (1905) proposed an equation for the relationship of mean effective pressure and speed based on a simple proportion with coefficients peculiar to each engine. Dalby's mean effective pressure curve of 1905 for the locomotive "Schenec-tady" is a straight line cutting the zero ordinate at a speed almost within the range 250–400 r.p.m. Such a locomotive would be unable to move itself on the level at a speed of 80 m.p.h., no matter how big its boiler or how large its cylinders. To-day a locomotive has been built capable of hauling a train of 1000 tons weight at a speed of 100 m.p.h. on the level.[2]

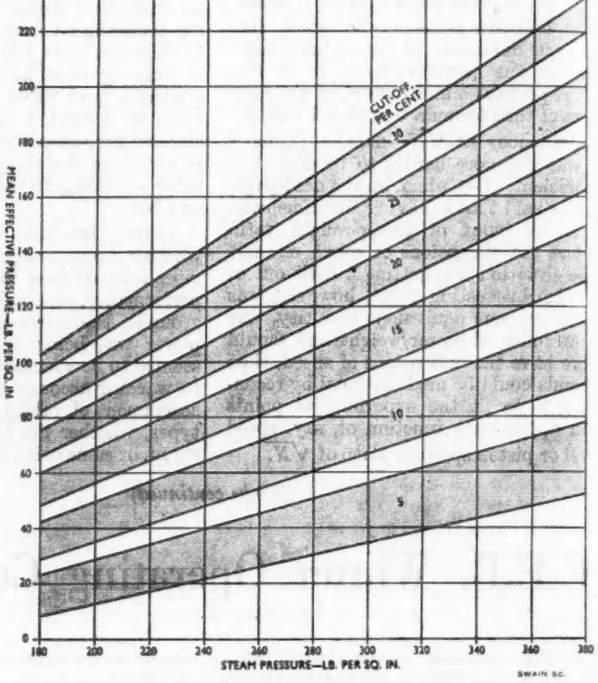
Though Dalby's equation was of doubtful validity over the higher speed range, it did indicate in a general way the state of locomotive design of that day, and the attenuation of the indicator diagram at express speed was so great and so variable as to render any conclusions to be drawn from calculated mean effective pressures of purely academic interest. To-day, the rate of deviation of the mean effective pressure with increase of speed still varies widely, and is the most important characteristic of the engine, but in the best designs it has been



Basis.—Exhaust pressure, 18 lb per square inch abs.; compression point as given by inset graph; law of expansion, $PV^{1.33}$ = const.; law of compression, $PV^{1.2}$ = const.

Each shaded band gives the mean effective pressures corresponding to the cut-off indicated, for percentage clearance spaces of 10 per cent (lower line) to 15 per cent (upper line). Values for intermediate clearances may be obtained by interpolation.

Fig. 1—*Calculated Mean Effective Pressures for Various Steam Pressures and Cut-offs (Clearances 10–15 per cent)*



Basis as for Fig. 1. The lower line of each shaded band gives the mean effective pressure for 5 per cent clearance, and the upper line for 10 per cent clearance.

Fig. 2—*Calculated Mean Effective Pressures for Various Steam Pressures and Cut-offs (Clearances 5–10 per cent)*

* Institution of Mechanical Engineers, February 21, 1947. Abstracted.

† Mechanical Engineer, Plant Engineering Division, British Iron and Steel Research Association.

An alphabetical list of references is given in an appendix.

[2] The four-cylinder "Duplex" locomotive built for the Pennsylvania Railroad by the Baldwin Locomotive Works, described in a paper to the New York Railroad Club in May, 1945, by R. P. Johnson, chief engineer of the Baldwin Locomotive Company.

reduced to such an extent that an analysis, such as is attempted in the first part of this paper, of the relationship between mean effective pressure and the boiler pressure, cut-off and clearance, together with the corresponding cylinder efficiencies, becomes of great practical importance, especially in designing locomotives for relatively higher pressures.

Basic Locomotive Data Graphs

Due to the wide and variable deviations from the theoretical indicator diagram which in the past were characteristic of locomotive performance, such broad data as were generally accepted were based simply on the boiler pressure. The best known is the universally accepted tractive effort formula which assumes that the greatest pressure that can be exerted in the cylinders is 0·85 of the boiler pressure. Even comparatively modern formulæ for power such as those of Cole (1914), Kiesel[3] (1915) and Lipetz (1933) are based on factors unrelated to cut-off or clearance. Cole employed empirical speed factors by which the percentage of the maximum tractive effort available at each speed is estimated; Kiesel used an expansion ratio which is not the indicated cut-off, but the ratio of the weight of a cylinder-full of steam to the weight of steam supplied per stroke on the basis of the assumed evaporation rate; while Lipetz's method was derived from Goss's formula and was based primarily on evaporative power.

It is hoped to show in this paper that by basing curves of mean effective pressure over a range of speed on the calculated mean effective pressure for the appropriate conditions, as was done by Dalby, a more exact expression for power can be deduced which, by the use of an appropriate coefficient, can be universally applied to locomotives of widely differing types. Such a method is more in accord with fundamental theory, and for this reason alone is less dependent on empirical relationships which may hold only for a particular phase or type of locomotive design. Its value is greatly enhanced by the fact that modern valve gears give more precise and finer control over the expansion ratio than was formerly the case.

If, moreover, the actual mean effective pressure at speed is commensurate with the calculated mean pressure, as is the case in the most advanced designs, then a number of conclusions of great importance in designing locomotives for higher steam pressures can be drawn from such calculated data, as will be shown.

Relationship of Mean Effective Pressure to Steam Pressure and Cut-off.—Fig. 1 is the basic data sheet showing calculated mean effective pressures for all steam pressures from 120 lb per square inch to 320 lb per square inch and over the whole range of economical cut-offs, from 5 per cent to 50 per cent. It also gives the data for percentage clearance spaces from 10 to 15 per cent. To avoid overlapping, data for clearances down to 5 per cent are given in Fig. 2, and as these are normally only applicable to compound locomotives, they are only given for cut-offs up to 30 per cent and for the higher range of steam pressures. Mean pressures for intermediate clearance percentages can be obtained within the general limits of accuracy of the graphs by linear interpolation.[4]

The main assumption necessary in making these calculations relates to the point of compression. The inset curve in Fig. 1 gives the relationship between cut-off and compression used. Radial valve gears give a relationship of this nature, and for practical reasons such a relationship would be desirable with any type of gear. It gives maximum efficiency at early cut-offs, which correspond to normal running at speed, and it sacrifices efficiency to extra power at the late cut-offs used for starting or at slow speeds. Thus it is also the ideal relationship on theoretical grounds. The curve is typical of a modern Walschaerts gear. It also gives results which are not appreciably affected in the case of a compound locomotive with two sets of gears, each operating at a late cut-off, if the equivalent overall cut-off is used in reading the total m.e.p. from the main graph.

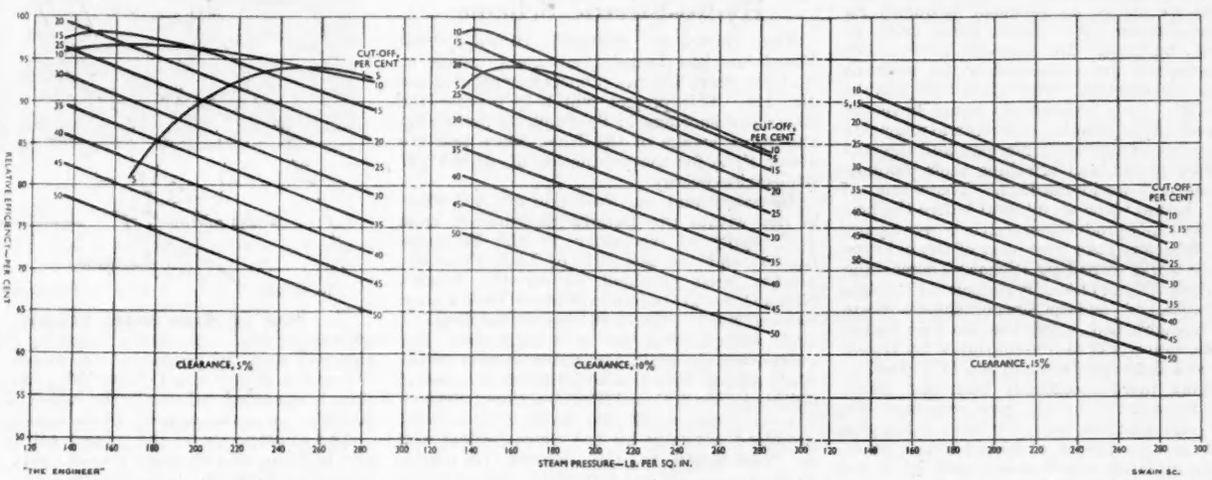
The other assumptions relate to the exhaust pressure and the laws of expansion and compression. The exhaust pressure has been fixed at a constant pressure of 18 lb per square inch abs. This is about the minimum attainable in practice at speed. With increasing power it is bound to rise, of course, but that is only part of the general attenuation of the indicator diagram for which these curves are intended to provide a basic standard of comparison. The law of adiabatic expansion of superheated steam is taken to be $PV^{1.33}$=const.[5] Theoretically the steam at the end of expansion is generally a little below saturation point, but in practice as a result of throttling it is usually slightly above saturation. In this instance it has been thought advisable to make a compromise between theory and practice and a law of compression $PV^{1.2}$=const. has been assumed. The effect on the calculated mean effective pressure is in any case small.

Effect of Clearance on Mean Effective Pressure.—It will be observed that at the earlier cut-offs necessary for economical working in the higher range of pressure, the percentage of clearance space has a very considerable effect. For modern locomotives working at a high expansion ratio this effect cannot be neglected in any calculations of power based on cylinder dimensions. It is of importance to know also the effect of clearance on the steam action in the cylinder as otherwise the increase in power may be illusory.

Relative Cylinder Efficiency at Increased Pressure.—The calculation of the relative efficiencies corresponding to the curves in Figs. 1 and 2 is a simple matter. The weight of steam remaining in the clearance space at the point of compression can be calculated from its volume (clearance+compression), its pressure and its state. To avoid the introduction of any arbitrary element its state is taken strictly as that given by steam tables after adiabatic expansion between the pressures concerned. The steam supplied per stroke is then the amount of steam at boiler conditions less the amount of steam trapped at compression. It is necessary only to know the steam temperature at admission. In practice this varies greatly, even in the same locomotive, with the rate of evaporation. For the purpose of a basic comparison, however, a single steam temperature may be taken for all conditions, and a mean steam temperature of 600 deg. Fah. (315 deg. Cent.) has been selected. The relative efficiency is the amount of work done per pound of steam at the calculated mean effective pressure compared with the work done on the Rankine cycle by a pound of steam in the same state, from boiler to exhaust pressure.

In Fig. 3 the relative efficiencies are plotted over the same range of boiler pressures and cut-offs as in Fig. 1, for 5, 10 and 15 per cent clearance respectively. The drop in the early cut-off curves at low boiler pressures is due to the expansion lines falling below the exhaust lines in these extreme conditions. These curves show that with the same clearance it is necessary for a locomotive with a boiler pressure of 250 lb per square inch to be worked at effective cut-offs from 20 to 30 per cent of the stroke shorter than a locomotive with a boiler pressure of 180 lb per square inch, in order to maintain the same relative cylinder efficiency. Put in another way, if a locomotive with a steam pressure of 250 lb per square inch is normally worked at the same effective cut-off as a locomotive with a pressure of 180 lb per square inch, say, 15 per cent cut-off at full speed, the relative cylinder efficiency will be 7 per cent less. As the Rankine cycle[6] efficiencies for the two pressures are 20·3 and 18·4 per cent respectively, this means that the effect of the reduced expansion ratio nearly nullifies the gain in efficiency due to the higher pressure, the respective cylinder thermal efficiencies being 17·3 and 17·0 per cent.

(To be continued)



Basis.—Mean effective pressure as for Figs. 1 and 2. Steam temperature at admission, 600 deg. Fah.

FIG. 3—*Relative Cylinder Efficiencies for Various Steam Pressures and Cut-offs*

[3] Published by A. J. Wood (1925).

[4] It should be explained that a high degree of accuracy is not necessary for any of the purposes contemplated in this paper, and all the calculations have been performed by a 10in slide rule and four-figure logarithms.

[5] Schüle, W. "Technical Thermodynamics," pages 380–1. All the data in this paper are valid only for superheated steam.

[6] The Rankine efficiency is throughout reckoned in this paper as the adiabatic heat drop between the boiler pressure and the exhaust pressure (18 lb per square inch abs.) divided by the heat available above the liquid temperature corresponding to the exhaust pressure. It is true that in locomotives the feed water temperature is generally nearer the temperature of the atmosphere than that of the exhaust steam, but partial feed water heating is frequently practised. This does not, of course, affect the values of the relative cylinder efficiencies.

South Wales Steel Industry Development

DETAILS of the plans for the development of the steel sheet and tinplate industry in South Wales were disclosed by Mr. G. H. Lever, chairman of Richard Thomas and Baldwins, Ltd., in a speech to the Port Talbot and Aberavon Chamber of Trade on Thursday, February 6th. The scheme includes, in addition to the erection of a continuous hot strip mill at Margam, already announced by Guest, Keen and Baldwins, Ltd., the construction of two cold reduction mills with appropriate tinning facilities at Llangyfelach in the Swansea district and at Trostre in the Llanelly area. A third mill for the production of cold reduced sheets, including extra wide sheets, is also envisaged, though its exact location has not yet been decided.

Mr. Lever said that the scheme was to be undertaken by a new company to be known as the Steel Company of Wales, the assets of which would be provided by Richard Thomas and Baldwins, Ltd., Guest, Keen and Baldwins Iron and Steel Co., Ltd., Guest, Keen and Nettlefolds, Ltd., Llanelly Associated Tinplate Companies, Ltd., and John Lysaght, Ltd. The Briton Ferry Steel Co., Ltd., had expressed itself wholly in favour of the project, but had decided to utilise its financial resources for the development of its steel, rather than its tinplate, business. The financial needs if the new company are estimated to be approximately £50,000,000. The Steel Company of Wales, Mr. Lever continued, would have the responsibility of planning, erecting and managing the new hot strip mill at Margam and the cold reduction plants, and of selling their products in home and world markets. There was, of course, bound to be an interval before the new mills came into production, and the new company would therefore take over most of the oid type tinplate works owned by Richard Thomas and Baldwins, Ltd., and Llanelly Associated Tinplate Companies, Ltd., and the Newport sheet works of John Lysaght, Ltd., as well as the Port Talbot and Margam works at present owned by Guest, Keen and Baldwins Iron and Steel Co., Ltd.

Dealing more specifically with the plants to be constructed by the new company, Mr. Lever said that the hot strip mill at Margam would have an output of 20,000 tons a week, and the intention was that it should roll a coil weighing 15,000 lb—a larger coil than was at present rolled anywhere in the world. The output of the Port Talbot and Margam coke ovens and blast furnaces would be doubled, and the ingot production of those works, Mr. Lever explained, would be trebled as a result of the erection of the new melting shop at Margam. The total horsepower used at the Margam hot mill was estimated at 46,000, compared with 42,900 used at the Irvin mill of the United States Steel Corporation. Other features of special interest were that the melting shop and slab heating furnaces would be oil-fired, and that the coils from the Margam strip mill would be conveyed in specially designed 65-ton wagons. Plates would be finished to an accuracy superior to anything yet produced in this country.

Turning to the new cold reduction plants, Mr. Lever indicated that their main features would be their sturdy construction and their speed of up to 4,000ft per min., which was very much higher than that of the Ebbw Vale mill. The buildings at Llangyfelach and Trostre would cover one million square feet, and the cold reduction plants there would each require about 2,000,000 gallons of water a day.

Mr. Lever explained that the project formed a part of the British Iron and Steel Federation's plans for the modernisation of the steel industry. At present, the scheme was being considered by the Steel Board and it was hoped that a favourable decision might soon be forthcoming. He could not say definitely what period would elapse before the new plant was in production, for although the engineering possibilities of the scheme were two and a-half to three years, materials and labour were in short supply, and furthermore, it was the Government that would decide on the degree of priority to be accorded to the project. If everything went as was hoped it would be four to four and a-half years before the new plant was in full production. Meanwhile, there would be employment for many thousands of people on the building and engineering work at the Port Talbot and Margam sites, for the new buildings would cover an area of 2,000,000 square feet. As much of the new plant as possible, Mr. Lever stated, would be purchased in this country, but there were certain items which could be obtained only in the U.S.A., and it was hoped that the Treasury would give assistance to the scheme, in such ways, for instance, as giving permission for plant to be imported from the U.S.A. duty-free.

The success of the erection of the new plants and of their subsequent operation, Mr. Lever added, would depend on the amount of co-operation the Steel Company of Wales received. The co-operation of the National Coal Board was important in connection with adequate supplies of coal of the right quality and the right price; satisfactory arrangements for the supply of power would need to be made with the electricity undertakings and with the railways for efficient transport at reasonable rates.

North of Scotland Glen Shira Hydro-Electric Scheme

THE North of Scotland Hydro-Electric Board has just issued preliminary details of its Glen Shira scheme (Constructional Scheme No. 12). This project will help to ease the electricity shortage in Scotland by harnessing the upper waters of the River Shira and the River Fyne for the production of 44,000 kW of electrical energy.

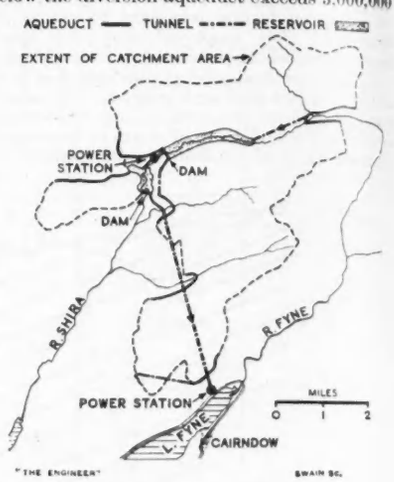
Inveraray and the west side of Loch Fyne is not within the Board's distribution area, but supply of electricity to the Cairndow district and the east side of Loch Fyne has already been provided for by the Board's North Cowal Distribution Scheme (Distribution Scheme No. 7). The backbone of that distribution scheme will be a transmission line connecting the main generating station of the Shira scheme with the Loch Striven generating station in South Cowal (Constructional Scheme No. 4). The 80,000,000 units of electricity produced annually by the Shira project will be transmitted to the Board's Inveruglas switching station and from there will go to the Central Electricity Board's Grid. Local demands will, however, have priority over export.

During construction, the Glen Shira project will provide direct employment for a large number, reaching, at the peak, 2000, and preference will be given to local labour. The scheme is estimated to cost about £3,250,000

Two new lochs will be created in the hills above Loch Fyne. One will be created by a dam at Sron Mor in upper Glen Shira, 1125ft above sea level. This reservoir will draw water from the River Shira and its tributary Alt na Sithean, and the head waters of the Rivers Fyne and Cladich. The water discharged from this main storage loch will pass through a small power station with an installed capacity of 4000 kW. It will then pass to a subsidiary loch 965ft above sea level, which will be formed in a natural basin about a mile downstream. The lower loch will collect water from a lower catchment area, which will be taken through a tunnel 4½ miles long, and a pipeline to the main generating station.

The main station, which will have an installed capacity of 40,000 kW, will be situated on the main Arrochar-Inveraray road at Clachan near the head of Loch Fyne. A bridge will be required to carry the road over the tailrace.

To preserve the stock of salmon and sea trout, the Board has agreed to maintain in the River Shira a flow of not less than 8,000,000 gallons per day, measured just above the junction of the River Shira and the Kilblaan Burn, one of its major tributaries. No water will be abstracted from the River Fyne until the flow below the diversion aqueduct exceeds 3,000,000



MAP OF GLEN SHIRA SCHEME

gallons per day. A gradually increasing proportion will then be abstracted by means of an automatic device until 7,000,000 gallons per day is exceeded, when all the water will be diverted up to the capacity of the aqueduct.

The construction of the project will involve the building of two main access roads. One will start from the Inveraray-Dalmally highway near Cladich and will branch to the two dams. The other main access road will start at the school in Glen Shira near Ellerigbeg and finish at the aqueduct which crosses the Brannie Burn. Constructional Scheme No. 12 also details the route of the single circuit 132,000 V transmission line which will pass through Glen Kinglas to the Inveruglas transforming station near Loch Sloy.

The accompanying map illustrates the layout of the scheme and the catchment area; another accompanying engraving gives an impression of the proposed main dam. The consulting engineers for the scheme are Mr. James Williamson, and Messrs. Babtie, Shaw and Morton, of Glasgow.

IMPRESSION OF GLEN SHIRA DAM

Expansion Rail Joint for London Transport Lines

MACHINE-FINISHED rail joints are now being incorporated in the permanent way laid by the London Passenger Transport Board on the extensions of the Central line. The problem of the rail joint is of particular interest to underground railway engineers, in view of the important part played in the production of noise by train wheels passing over joints and

"EXPANSION SWITCH" RAIL JOINT

the consequent importance in any noise-reduction treatment to reduce the number of joints and the gaps between rails. Underground engineers have to face, in common with all permanent way engineers, the normal maintenance difficulties at rail ends, accentuated by the very heavy traffic composed entirely of multiple-unit stock passing almost continuously for nineteen hours a day.

In the last ten years the practice of welding together 60ft rail lengths has been subjected to extensive experiments in the Board's system, and welded lengths of 300ft are now standard for new construction and normal relaying work. This does not apply at places where curves of less than 10 chains radius are encountered, where the necessity for frequent rail renewals makes the standard 60ft rail preferable. The length of 300ft has been chosen because this is the greatest that it is practicable to unload from a train standing between two signals, and it is also the most convenient length for transport to the site.

It has hitherto been the practice either to join these rails with fish-plates of the normal four-bolt type, with a gap left to allow for expansion, or to use overlapping joints of the Brogden type.

The latest development, designed to overcome the movement in the joint produced by the weight of a train passing over it and to minimise the "batter" at the rail ends, is to machine all the contact surfaces between rails and fish-plates to produce a tight flush-fitting joint. In addition, the bolt holes in rails and fish-plates are jig drilled to ensure accurate fitting, and turned bolts of $1\frac{1}{4}$in diameter are used in place of the $\frac{7}{8}$in bolts employed in the standard joint. By these means a joint is secured which is as nearly rigid as possible. With the two rail ends butted up to each other, "batter" is reduced to a minimum, and the exact fitting of all the components prevents undesirable movement under traffic. These joints are also being used experimentally for 60ft rails on sharp curves where, as previously mentioned, it is undesirable to install the 300ft rail.

Laying what is virtually a continuous rail instead of a series of rails 300ft long has called for the provision of some new method of allowing for expansion and contraction due to variations of temperature. It has been found in practice that expansion of a 300ft rail is no more than twice that of a 60ft length, the tendency to expansion being distributed and resisted by the greater number of sleepers. Nevertheless, expansion cannot be ignored, and it is met in the new flush-ended track by provision of devices known as "expansion switches" laid at intervals of about half a mile. These switches, as the name implies, consist of rail ends joined in the form of a stock rail and a switch rail mounted on slide chairs and held together by specially designed clips. This arrangement, to be seen in the photograph we reproduce, permits relative longitudinal movement in the two rails of up to 6in. Most of this movement takes place when lengths are unkeyed in the course of normal maintenance at the beginning of warmer weather and the compression is relieved by the release of stresses; a corresponding operation to permit contraction takes place in the autumn.

A Diesel-Electric Shunting Engine

A NEW diesel-electric shunting locomotive, built by Crompton Parkinson, Ltd., is now undergoing trials under actual service conditions. This locomotive, which weighs some 45 tons, has a maximum tractive effort of 30,000 lb and is capable of speeds up to 40m.p.h.

It has a 400 h.p. "V" type engine, designed for easy accessibility to facilitate maintenance and inspection. A "Crompton-Armstrong" automatic load regulator is fitted to the engine generator set to eliminate the danger of over loading. The d.c. generator is flexibly coupled to the engine and the whole power unit is self-contained. In order to permit the easy removal of the power unit from the chassis the number of connections have been kept to a minimum. The traction motors are axle hung with high-ratio single-reduction gears, and are force ventilated by air from an engine-driven blower.

The mechanical construction of the locomotive, which is illustrated below, is quite simple. It consists essentially of a heavy plate frame chassis and three driven axles carried in roller bearing axleboxes.

The control gear, which has been specially developed, is so arranged that by means of one switch the locomotive can be converted from a hump shunter to a transfer or branch line engine running at 30 or 40 m.p.h. Special attention has been given to the comfort of the driver, and the cab is designed to give maximum vision with complete weather protection. It is heated and both driving positions are provided with an adjustable seat.

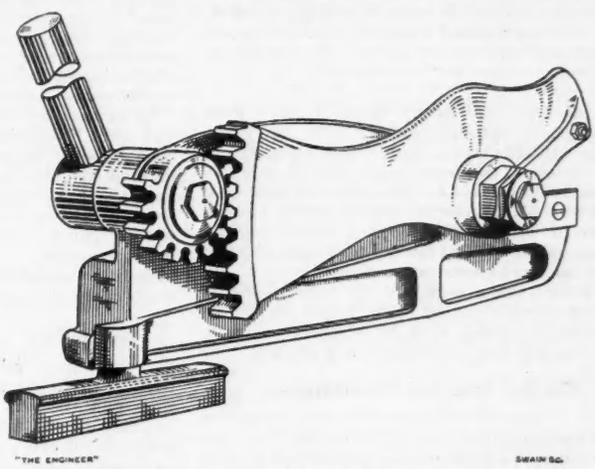
It is pointed out by the manufacturers that the engine, generator, traction motors, wheels, axles and axleboxes used in this design are suitable standards which could be incorporated in a range of diesel-electric railcars, motor trains, shunting or main line locomotives.

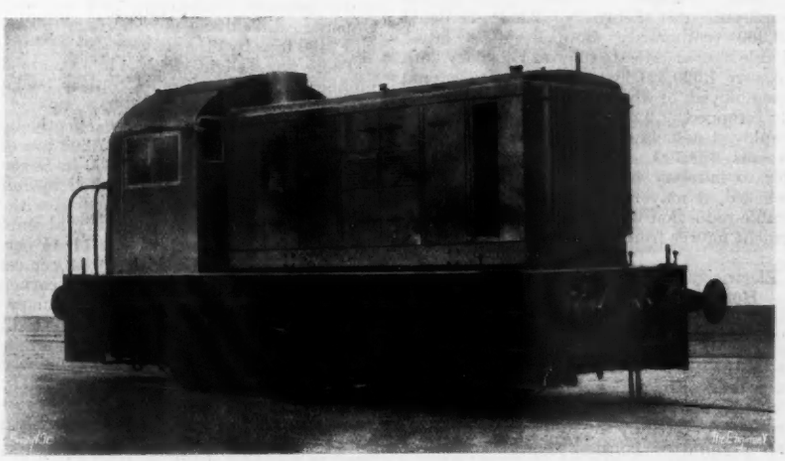
A Small Hand Shearing Machine

THE production of a useful little hand-operated shearing machine, known as the "Hilshear," has been resumed by Hills (Patents), Ltd., Chenies Mews, Pancras Street, London, W.C.1. It is intended for cutting mild steel bars up to 2in by $\frac{1}{4}$in, plate up to 10 S.W.G., and rod up to $\frac{3}{8}$in diameter.

As can be seen from the drawing we reproduce, the construction of the machine is quite simple. It consists of a drop-forged steel body, near the front of which is pivoted a shearing arm. This arm is actuated through a rack formed on its rearmost extremity by a pinion which is turned by a substantial hand lever, 2ft long. A number of teeth has been omitted from the pinion in order that its position in relation to the rack may be easily altered to set the shear jaws according to the thickness of material to be cut.

In the rear of the body is a hole, in which various fittings can be locked to fix the machine in a vice or on to girders or anvils. Another attachment enables the machine, which weighs just over 13 lb, to be used as a hand shears.





DIESEL ELECTRIC SHUNTING LOCOMOTIVE

Industrial and Labour Notes

Employment and Unemployment Statistics

A day or two after our last issue had gone to press, the Ministry of Labour published statistics relating to employment in Great Britain in December, 1946. In that month the total working population numbered 20,247,000, a decrease of 77,000 compared with the preceding month. At the end of December, however, the total working population was greater than at mid-1939 by 497,000 (197,000 men less and 694,000 more women).

The number of people employed in industry in December was 18,033,000 (12,440,000 men and 5,593,000 women), which was 113,000 more than at mid-1939. There were 459,000 people engaged in the manufacture of equipment and supplies for the Forces and 17,574,000 working in home civilian industries and services and manufacture for export. In this latter group the number employed in December was about 600,000 above the normal pre-war level. An analysis of the manufacturing industries shows that there were 5,033,000 people engaged in the production of goods for the home market, and 1,466,000 engaged in manufacturing for export. It may be remarked that the number of people employed in manufacturing for export in December exceeded the mid-1939 figure by 476,000.

Unemployment figures included in the same statement relate to January 13th, on which date 401,249 insured people were registered as unemployed, compared with 362,976 so registered on December 9, 1946. The January total included 47,163 married women, some of whom have probably retired from industrial employment, and 27,777 ex Service personnel who had had no employment since demobilisation. In addition, there were on the unemployment registers on January 13th 14,521 uninsured people, including 8538 boys and girls under sixteen who had not then entered industry.

The Fuel Crisis and Unemployment

An early effect of the fuel crisis was the rendering idle of many thousands of workers employed in industrial concerns dependent upon electric power, and since the cuts were first imposed on February 10th the Ministry of Labour has from time to time published the numbers of those temporarily thrown out of work.

Up to and including February 18th, the number of people claiming unemployment benefit was 1,272,000, and in addition it is estimated that 842,500 workers were "stood off" and were not claiming benefit. On February 22nd the number of insured persons registered as unemployed was 1,869,405, but by that date the estimated number of workers "stood off" had dropped to about 503,800. The total of insured persons registered as unemployed on February 22nd included 1,413,369 temporarily stopped. The latest available figures indicate that on February 26th there were 1,520,321 insured persons registered as unemployed, of whom 1,055,242 were temporarily stopped. The estimated number of unemployed not claiming benefit on February 26th was 228,700. With the restoration of power to industry in all regions on Monday, March 3rd, it may be anticipated that a considerable reduction will be shown in the unemployment figures from that date.

Electricity Supply and the Staggering of Hours

The Minister of Labour's Joint Consultative Committee, consisting of representatives of the British Employers' Confederation and the Trades Union Congress, met on Wednesday of last week and devoted its attention mainly to problems created by the fuel shortage.

The Committee considered the statement issued by the Prime Minister on the Central Electricity Board's warning that it would be impossible for the electricity generating stations to carry the load required by industry without a staggering of hours and a substantial amount of night-shift working. The position of the electricity supply undertakings was explained to the Committee by a representative of the Central Electricity Board. Recognising that the existing power plants are unable to cope with the load required for industry and domestic purposes, the Joint Consultative Committee expressed the view that the Government should give urgent and serious attention to the most rapid means of increasing electricity plant.

Iron and Steel Production

Iron and steel production in the United Kingdom in January showed a considerable increase on that in January, 1946, although the improvement was limited by the reduction in coal allocations which began on January 20th. The weekly average output of pig iron in January was 150,100 tons, corresponding to an annual rate of 7,806,000 tons. In January, 1946, the average weekly output was 143,600 tons. Production of steel ingots and castings averaged 239,800 tons a week in January, representing an annual rate of 12,470,600 tons. Steel production in January, 1946, averaged 228,600 tons a week.

In announcing these figures, the British Iron and Steel Federation says that it has not yet been possible to work out the effect of the reduced coal allocation and the electricity cuts upon the iron and steel industry. The effect of the weather upon transport has also been causing grave concern. Every effort is being made, however, to overcome these difficulties, including conversion, where possible, to oil firing in the steel furnaces.

Coal Output

Figures relating to coal production in Great Britain during the month of January were published by the Ministry of Fuel and Power on Saturday last, together with statistics on manpower in the mines and coal consumption and stocks, and also preliminary output figures for the month of February.

In the four weeks ended January 25th, the saleable output of mined coal averaged 3,579,700 tons a week, compared with 3,511,200 tons a week in December, and the January output of saleable opencast coal averaged 127,200 tons a week, compared with 118,400 tons a week in December. The total tonnage of mined coal lost in January is put at 168,000 tons a week, compared with a weekly average of 334,700 tons a week in December. Of the tonnage lost in January, 118,100 tons a week were accounted for by recognised holidays, 10,600 tons by disputes, 22,600 tons by accidents, breakdowns and repairs to machinery, 7300 tons by rail transport difficulties and shortage of wagons, and 9400 tons by other causes.

There was a slight increase in January in the number of wage-earners on colliery books, the weekly average being 693,800, compared with 692,200 in December. Those effectively employed, however, averaged 637,200 a week in January, compared with 642,800 in December. The output per man-shift worked in January was 2·81 tons at the face, compared with 2·79 tons in December, and voluntary absenteeism amongst coal face workers was 11·44 per cent in January, compared with 10·84 per cent in December. The number of wage-earners on colliery books at the end of January was 695,100, an increase of 2900 compared with December. Total recruitment to the mines in January is estimated as being 7500 workers, but the total wastage amounted to 4600.

The total inland consumption of coal in January averaged 3,974,000 tons weekly, compared with 3,936,000 tons in December. The total distributed stocks at the end of January amounted to 6,680,000 tons, compared with 8,466,000 tons at the end of December and 9,763,000 tons in January, 1946.

The provisional figures for February indicate that in the week ended February 22nd the output of deep-mined coal was 3,824,900 tons and of opencast coal 180,600 tons. These figures are the highest recorded for this year. The total distributed stocks at February 15th were 5,255,500 tons.

Private Trade with Germany

The Board of Trade has announced the lifting, as from March 4th, of the Trading with the Enemy Regulations, which have prevented United Kingdom firms from trading with Germany. This step was timed to fit in with similar action by the U.S.A., and refers only to exports from Germany. For the time being, imports into the British and American zones of Germany will be solely on Government account.

The Government's intention is that trade with Germany shall return as soon as possible to normal channels, and the degree of relaxation now announced means that contracts between German sellers and foreign buyers are permitted. The new procedure concerns imports of goods into the United Kingdom, including goods processed in Germany from materials supplied by United Kingdom firms, whether payment is made in cash or in kind. At present, only essential goods will be imported from Germany, such as machinery and other industrial equipment, chemicals, and some types of textiles. Payment for goods imported from the British and American zones will be in sterling, and all exports from the two zones will be priced and paid for in foreign currencies. Contracts will be scrutinised by the Export/Import Agency to see that appropriate prices are charged. Traders must obtain licences for all goods except those which may be imported from all countries under an open general licence, and importers should apply to the Sundry Materials Branch of the Board of Trade, 10, Old Jewry, E.C.2.

British Overseas Trade

Figures published by the Board of Trade on Tuesday, last, show that in the month of January the value of exports of United Kingdom goods was £91,200,000. Imports in the same month reached a total value of £121,400,000, and re-exports were £5,100,000.

The value of United Kingdom goods exported in January was in excess of the December figure, but on account of the Christmas holiday falling in the latter month, the comparison is not a good one. The January total, however, was approximately £900,000 below the November, 1946, figure, but was greater than that of any other month in 1946, apart from July. Allowing for the increase in prices, the volume of goods exported in January is estimated as being 12 per cent greater than in the comparable month of 1938. In November, 1946, the volume was 15 per cent greater, and in July, 1946, 20 per cent greater than in the corresponding months of 1938.

The T.U.C.'s Fuel Committee

When the General Council of the Trades Union Congress met on Wednesday, February 26th, various aspects of the fuel and power situation occupied a prominent place on the agenda. In the course of the discussions, emphasis was laid on the necessity for increasing coal output to meet the needs of the power-producing and all other industries. It was pointed out that the problem of increasing coal production was more than a question of manpower, as it involved also arrears in mechanisation and development. It was agreed to appoint a special sub-committee, which is to consider all matters relevant to the fuel and power problem and report at an early date to a special meeting of the General Council.

French Engineering News

(From our French Correspondent)

Paris, February 28th.

Since coal is probably the most urgent single need in France to-day, the greatest efforts are being made to economise in this direction, and it has been estimated that 600,000 tons a year will be saved when the first stage in the Paris–Lyon–Marseilles railway line has been electrified. Already work on the line has begun, and although about ten years will be needed for completion, by 1950 the Paris and Lyon section will be electrified.

Electricity for the line will be supplied by the Génissiat hydro-electric station, which is now nearing completion. The Paris steam engine depot will be replaced by an electric locomotive yard, which will obviate all smoke in the neighbourhood of the Gare de Lyon. Work has started on the project both in Paris and Lyon. Each stage, as it is finished, will be put into service. The first two stages will be Laroche and Dijon and then Paris and Laroche. The trains, which will comprise a greater number of carriages, will save 1 h 20 min in the Paris and Lyon journey.

The programme will have to overcome several difficulties, including the widening of the railway right of way in order to erect catenary poles every 30 m to 50 m. Tunnels will have to be enlarged to allow carriages and trolleys to pass through. This will be done by lowering tracks under each tunnel rather than by raising the arches. It will also be necessary to convert light signalling apparatus for operation by d.c. instead of a.c., and all the present telephone installation will have to be modified to avoid difficulties produced by high-tension current. Tracks will be modified and adapted to new speeds, and since the trains will be wider, station platforms will have to be altered. From Paris to Lyon, for example, it will be necessary to lower tracks 122 times, raise 42 tunnels, to re-align 546 km of track and to shift 1,650,000 cubic metres of earthwork.

* * *

In December, 1946, the steel industry received considerably less coke than had been expected. Production was considerably held up and several blast-furnaces were in difficulties. However, production was maintained at nearly the November level. Provisional figures give the following production for the month;—Iron, 377,000 tons with fifty-nine blast-furnaces; crude steel, 443,000 tons, of which 246,000 tons was Thomas, 167,000 tons Martin, 33 tons electric, 2000 tons Bessemer and Creusot; sheet steel, 312,000 tons. Altogether the year marked a considerable advance over 1945, although the 1938 level has not been reached. But at the Forges et Acieries du Nord et de l'Est an improved allocation of coal and coke led to production being greater in the last three months of 1946 than the corresponding quarter of 1938. The company is to combine with the Forges et Acieries de Denain-Anzin in a rationalisation programme for all present metallurgical production. Economies resulting from the merger are expected to be considerable. New processes will use only 1100 kg of steel in producing 1 metric ton of fine sheet, compared with 1350 kg used at present. Coal economy is expected to amount to 50 per cent, and labour will be reduced by 75 per cent or more.

* * *

When the dam on the River Maulde has been constructed the geography of the Limousin *departement* will have been considerably altered. Instead of the River Maulde flowing into the River Vienne, the Vienne will increase the flow of the Maulde, after supplying the Foix-la-Montagne and Chaumet dams. Altogether, the Maulde dam will hold up 100 million cubic metres of water, which will pass through a forced conduit to an underground plant some kilometres away. The new dam will supply two plants with a total output of 100,000 kW. Altogether, there will be three reservoirs, the main one covering 900 hectares. The plant will work on a 300-metres head. The great artificial lake which will be created will submerge several villages, and a certain amount of local resistance has been voiced against the project.

Notes and Memoranda

Rail and Road

Oil-Burning Locomotives.—The Minister of Transport stated a few days ago that eighteen locomotives had so far been equipped for oil burning in this country. It was proposed eventually to equip 1217.

Swedish Railway Electrification.—According to *The Anglo-Swedish Review*, electrification of the Swedish State Railways is to be suspended after work now in hand has been completed. The reasons given are the lack of necessary materials and a shortage of labour.

Ferries in Great Britain.—The Standing Joint Committee of the Royal Automobile Club, the Automobile Association and the Royal Scottish Automobile Club has just completed a survey of the ferries in Great Britain, and a report has been submitted to the Ministry of Transport. The report contains suggestions for improvements of the ferries, alterations in ownership and control, revised charges, improved waiting facilities, increased safety precautions, additional services, &c. An important general recommendation is that as a general principle all ferries should be operated and owned by the appropriate highway authority.

Fuel Efficiency on the Footplate.—As part of its efforts to economise in the use of locomotive coal, the London and North-Eastern Railway has appointed specially selected engine drivers as fuel economy inspectors. These men, after long and successful years on the footplate, now ride hundreds of miles daily teaching firemen, particularly new recruits, the art of placing each piece of coal in the firebox, so that in burning, it produces the maximum amount of steam. Drivers, too, reap the benefit of the experience that these men bring to their job for there is a knack about the way an engine's valve motion is adjusted whilst running that extracts the last ounce out of the steam pressure.

Air and Water

Gold Coast Hydro-Electric Power.—The Secretary of State for the Colonies said recently that an investigation of the hydro-electric potentialities of the Volta River, Gold Coast, had been proceeding for some months, and it was expected that the result would be available in about a year's time.

The Severn Ferry.—The Minister of Transport was asked recently whether the existing ferry service between Aust and Beachley would be maintained while the Severn Bridge was under construction. He replied that the necessary arrangements were being made for the ferry to remain in operation during the building of the bridge.

Shanghai Dockyard.—Plans are being made by the Chinese National Resources Commission for the construction at Shanghai of a dockyard capable of producing vessels of up to 30,000 tons. The equipment of the new dockyard will be drawn mainly, it is stated, from the 50,000 tons of Japanese reparations to China, a large part of which consists of shipbuilding machinery.

Marine Radio Conference.—The U.S.A. has invited sixty nations to attend an international meeting on marine radio aids to navigation to be held in New York City and New London, Connecticut, for two weeks beginning on April 28th. It is stated that the aim of the meeting is to inform the world delegates on American policy in the field of marine radio aids to navigation and to demonstrate the progress made in this field. The meeting will include technical discussions on developments and demonstrations of the latest types of equipment such as loran and radar. The United States will be represented at the meeting by representatives of industry, education and the Government. Dr. W. L. Everitt of the University of Illinois will serve as chairman of the meeting.

Miscellanea

Utrecht Fair.—The Royal Netherlands Industries Spring Fair at Utrecht, planned to take place from March 11th to 20th, has been postponed until April 15th to 24th.

The Chemical Engineering Group.—The Chemical Engineering Group announces that its annual general meeting will be held at the Waldorf Hotel, Aldwych, W.C.2, on Wednesday, May 28th. A dinner will follow at which the Guest of Honour is to be the Marshal of Royal Air Force, Lord Tedder.

The London Power Company.—The London Power Company celebrated its twenty-first Anniversary at a dinner at the Café Royal, London, on February 5th, at which about 400 members of the staff were present. In the absence through illness of the chairman of the company, the Earl of Lytton, the deputy-chairman, Major H. Richardson, presided.

Lease Lend Tools.—The Minister of Supply announces the removal, as from February 18th, of the special conditions imposed on the sale of Lease-Lend machine tools, small tools and hand tools by registered merchants. Copies of the Control of Machine Tools (No. 16) Order, 1947, and the Control of Hand Tools (No. 5) Order, 1947, giving effect to the revocation of these conditions may be obtained from H.M. Stationery Office, price 1d.

Price of Copper.—The Minister of Supply has made the Control of Non-Ferrous Metals (No. 27) (Copper, Lead and Zinc) Order, 1947, which came into force on February 28th. This Order increases the maximum price of copper by £10 per ton. The price of high-conductivity electrolytic copper is therefore increased from £117 to £127 per ton. Prices for other forms of copper are correspondingly adjusted. Inquiries concerning the matter should be addressed to the Directorate of Non-Ferrous Metals, 20, Albert Street, Rugby.

Iron and Steel Order.—The Minister of Supply has made the Control of Iron and Steel (No. 57) Order, which came into force on March 3rd. The Order amends maximum prices, the principal alterations being increases in the price of hematite pig iron, Scotch foundry iron, blast-furnace ferro-manganese, and bright steel bars, and galvanised sheets, wire rope, nails and commercial quality hot-finished seamless tubes. Ferro-alloys and high-speed steel are removed from price control. Copies of the Order (S.R. & O., No. 353, 1947) may be obtained from H.M. Stationery Office.

Transatlantic Wireless.—A notable event in Transatlantic wireless communication is contained in the news that Marconi's are to supply a powerful modern short-wave broadcasting transmitter with a special aerial system to the Eire Posts and Telegraph Department for Radio Athlone, to enable that station to extend its programmes to Canada and the U.S.A. The new transmitter is to be erected under the supervision of Marconi engineers and will work alongside other Marconi broadcasting transmitters supplied to Athlone some years ago. This service is expected to be heard on the air towards the end of 1947.

National Productive Efficiency Conference.—The Wolverhampton Section of the Institution of Production Engineers has arranged a conference on "National Productive Efficiency" which will be held tomorrow, March 8th, at the Technical College, Wolverhampton. The conference will be opened at 10 a.m. by Sir Norman Kipping, Director-General of the Federation of British Industries. An address on "Britain's Man-Power Budget" will be delivered by Sir Godfrey Ince, Permanent Secretary, Ministry of Labour, after which there will be group discussions on Man-power, Management and Plant. Following a luncheon at the Civic Hall, the conference will be resumed at 2.30 p.m. to discuss the work of the morning sessions, and at 4 p.m., Dr. H. Schofield, Principal of Loughborough College, will sum up the day's proceedings.

Electricity Cuts.—"The Central Electricity Board directed that Supplies of Electricity should be cut . . ." is the title of a pamphlet published recently by the Incorporated Association of Electric Power Companies. This pamphlet sets out to provide the supply companies' consumers with the facts relating to load shedding. It traces the origins of the existing shortage of generating plant, explains the supply industries' difficulties in their attempts to alleviate the shortage, and suggests the action that can be taken by the consumer and by the Government to provide a remedy. It is claimed that the statutory procedure for the planning, direction, and approval of new generating stations is becoming increasingly complicated, and results in serious delay. Further delay is caused by bottlenecks in the manufacture of plant. Whereas before the war two to three years was considered a reasonable period for the manufacture and installation of a large plant, four years is now regarded as the minimum time for the same work, with five years as the more normal. The pamphlet concludes by suggesting that the existing restrictions in ordering, manufacturing and installing new plant should be removed immediately and "first priority given to a first priority job of immense proportions."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association of Supervising Electrical Engineers

Tuesday, March 18th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Electrical Equipment of a Modern Liner," C. P. Harrison. 6.15 p.m.

Bradford Engineering Society

Monday, March 17th.—Technical College, Bradford. "Heat Treatment Furnaces," D. C. Gunn. 7.15 p.m.

Chemical Society

To-day, March 7th.—S. WALES BRANCH: University College, Swansea. "The Making of Missing Chemical Elements," F. A. Paneth. 6 p.m. (Joint meeting.)

Thursday, March 13th.—EDINBURGH BRANCH: North British Station Hotel, Edinburgh. "The Composition and Structure of Proteins," A. C. Chibnall. 7.30 p.m. (Joint meeting.)

Derby Society of Engineers

Monday, March 17th.—School of Arts, Green Lane, Derby. "Underground Derby." M. L. Francis. 7 p.m.

Illuminating Engineering Society

Tuesday, March 11th.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Lighting in Coal Mines," J. Ivon Graham. 6 p.m.

Institute of Economic Engineering

Friday, March 14th.—Cowdray Hall, Henrietta Place, W.1. "Economic Aspects of the Layout of a Plating Shop," H. Cann. 7 p.m.

Institute of Marine Engineers

Friday, March 14th.—Connaught Rooms, W.C.2. Annual Dinner. 6.30 p.m.

Tuesday, March 18th.—JUNIOR SECTION: The Polytechnic, Scarbrook Road, Croydon. "Combustion Turbines," J. Calderwood. 7 p.m.

Tuesday, March 25th.—85, The Minories, E.C.3. "Dryness of Steam and Priming in Marine Boilers," Com. (E) L. Baker, R.N. 5.30 p.m.

Friday, March 28th.—85, The Minories, E.C.3. Annual general meeting. 5.30 p.m.

Institute of Transport

To-day, March 7th.—N. IRELAND SECTION: Lombard Cafe, Belfast. "Air Commerce," D. F. McIntyre. 6.15 p.m.

Institute of Welding

Monday, March 10th.—N. LONDON BRANCH: The Polytechnic, Regent Street, W.1. "Flame Cutting Developments, Past, Present and Future," R. E. Dore. 7.30 p.m.

Friday, March 21st.—S. LONDON BRANCH: Technical Institute, Gravesend. "Detailed Design of Arc Welded Components," M. Riley. 7.30 p.m.

Institution of Civil Engineers

Tuesday, March 11th.—Great George Street, S.W.1. "Reduction of Ground Vibrations into Structures," J. H. A. Crockett and Rolt Hammond. 5.30 p.m.—S. WALES BRANCH: Assembly Room, The Town Hall, Newport. "Permanent Way Maintenance and Renewal," Lt.-Col. E. C. Cookson. 6 p.m.

Friday, March 21st.—BIRMINGHAM ASSOCIATION: Queen's Hotel, Birmingham. Annual Dinner. 6.30 p.m.

Institution of Electrical Engineers

Wednesday, March 12th.—S. MIDLAND STUDENTS: James Watt Memorial Institute, Great Charles Street, Birmingham. "Modern Hydro-Electric Power Stations," J. Fry. 6.45 p.m.

Wednesday, March 19th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "Velocity Modulation Valves," L. F. Broadway, C. J. Milner, D. R. Petrie, W. J. Scott and G. P. Wright. 5.30 p.m.

Saturday, March 22nd.—N. MIDLAND STUDENTS: Corporation Electricity Department, Whitehall Road, Leeds. "The Place of the Engineer in the Post-War World," Sir Arthur P. M. Fleming. 2.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, March 18th.—39, Elmbank Crescent, Glasgow. "The Standard Partially Fabricated 10,000 ton Tramp Vessel," J. Lenaghan; and "Coasters and Small Craft in the Wartime Merchant Shipbuilding Programme," J. Lenaghan and T. W. Davis. 6.30 p.m.

Institution of Mechanical Engineers

To-day, March 7th.—Storey's Gate, St. James's Park, S.W.1. "An Alternative Form of Pressure Vessel of Novel Laminar Construction," H. Birchall and G. F. Lake. 5.30 p.m.

Friday, March 14th.—Storey's Gate, St. James's Park, S.W.1. "A Contribution to the Solution of the Gas Turbine Problem," A. J. R. Lysholm. 5.30 p.m.

Friday, March 21st.—Storey's Gate, St. James's Park, S.W.1. "The Combination Torque-Converter and Fluid-Coupling Drive," B. J. Tams and A. L. Gatiss. 5.30 p.m.

Institution of Post Office Electrical Engineers

Wednesday, March 19th.—Faraday Building (South Block), Knightrider Street, E.C.4. "A Review of Compressed Air Technique and its Practical Applications," W. J. Ford. 5 p.m.

Institution of Structural Engineers

Thursday, March 27th.—11, Upper Belgrave Street, S.W.1. "Stress Distribution in Steel Portal Frame Knees," A. W. Hendry. 6 p.m.

Junior Institution of Engineers

To-day, March 7th.—WESTERN MEMBERS: Merchant Venturers Technical College, Unity Street, Bristol. "Liquid Spring Development," A. E. Bingham. 7.30 p.m.—39, Victoria Street, S.W.1. "Notes on Some Recent Developments in Combustion Engines and Turbines," J. Calderwood. 6.30 p.m.

Monday, March 10th.—N. WESTERN SECTION: Geographical Society, 16, St. Mary's Parsonage, Manchester. "Penicillin and Freeze-Drying Process," F. E. Bancroft. 7 p.m.

Friday, March 14th.—39, Victoria Street, S.W.1. "Fuel for Industry—Coal to Oil Conversion," J. Duguid. 6.30 p.m.

Friday, March 21st.—39, Victoria Street, S.W.1. Discussion: "Furnace Practice." 6.30 p.m.

Monday, March 24th.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. Presidential Address: "The Spotlight on Production," A. Roebuck. 7 p.m.

Wednesday, March 26th.—N. WESTERN SECTION: Engineers' Club, Albert Square, Manchester. Presidential Address: "Inspection," A. W. Sproull. 7 p.m.

Friday, March 28th.—39, Victoria Street, S.W.1. "An Engineer Visits Sweden," Hubert J. N. Riddle. 6.15 p.m.

London Association of Engineers

Saturday, March 15th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Anniversary Dinner. 6 p.m.

Manchester Association of Engineers

To-day, March 7th.—Engineers' Club, Albert Square, Manchester. "The Handling and Transport of Materials in a Modern Factory," W. L. Beeby. 6.45 p.m.

Friday, March 14th.—Grand Hotel, Aytoun Street, Manchester. Annual Dinner. 7 p.m.

Manchester Geological and Mining Society

Tuesday, March 11th.—Engineers' Club, Albert Square, Manchester. "Strata Control in Mines," D. W. Phillips. 3.15 p.m.

Newcomen Society

Wednesday, March 12th.—Inst. of Structural Engineers, 11, Upper Belgrave Street, S.W.1. "The Prehistory of the Hammer," H. H. Coghan. 5.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Wednesday, March 12th.—STUDENT SECTION: Bolbec Hall, Newcastle-on-Tyne. "Wave Resistance and its Analysis," J. F. Leathard. 6.45 p.m.

Friday, March 14th.—Mining Institute, Newcastle-on-Tyne. "Structural Investigations in Still Water on the Tanker "Newcombia" R. B. Shepheard and F. B. Bull. 6 p.m.

Royal Aeronautical Society

Friday, March 14th.—GRADUATES SECTION: 4, Hamilton Place, W.1. "Developments in Propeller Turbine Engines," G. J. C. Davies. 7.30 p.m.

Thursday, March 27th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The War in the Ether," Air Vice-Marshal E. B. Addison. 6 p.m.

Royal Institution of Chartered Surveyors

Monday, March 31st.—12, Great George Street, S.W.1. "Valuation Problems Affecting Licensed Property," S. Motion. 5.30 p.m.

Royal Institution of Great Britain

To-day, March 7th.—21, Albemarle Street, W.1. "Whither Paint?" L. A. Jordan. 9 p.m.

Friday, March 14th.—21, Albemarle Street, W.1. "The Character of London's Architecture." A. E. Richardson. 9 p.m.

Royal Statistical Society

To-day, March 7th.—INDUSTRIAL APPLICATIONS SECTION: E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "The Standardisation of Symbols and Nomenclature in Quality Control," R. F. Banister. 6 p.m.

Wednesday, March 19th.—BIRMINGHAM GROUP (INDUSTRIAL APPLICATIONS SECTION): Chamber of Commerce, 95, New Street, Birmingham. "Some Aspects of Statistical Computing," H. O. Hartley. 6.30 p.m.

Sheffield Metallurgical Association

Tuesday, March 11th.—198, West Street, Sheffield. "Some Anomalies and Refinements in Diamond Pyramid Hardness Testing of Heavily Cold Rolled Strip," T. B. Crow and J. F. Hinsley. 6.30 p.m.

Tuesday, March 25th.—198, West Street, Sheffield. "Reflections on Wartime Steel Inspection," H. Wrighton. 6.30 p.m.

Sheffield Society of Engineers and Metallurgists

Monday, March 17th.—Royal Victoria Station Hotel, Sheffield. "The Underground Mechanisation of Coal Mines," J. Sinclair. 6.15 p.m.

Society of Chemical Industry

Thursday, March 20th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry (House, 1, Grosvenor Place, S.W.1. "Prefabricated Houses: Some Chemical and Physical Problems," H. Rose. 6 p.m. (Joint meeting.)

Personal and Business

SIR FREDERICK STEWART has joined the board of S. Smith and Sons (England), Ltd.

DR. F. W. HAYWOOD has been appointed technical director of Wild, Barfield Electric Furnaces, Ltd.

MR. W. K. HUTCHISON has been elected to the court of directors of the Gas Light and Coke Company.

BRIGADIER C. A. LANGLEY has been appointed an Inspecting Officer of Railways in the Ministry of Transport.

G.P.U., Ltd., Palace of Engineering, Wembley, has obtained a site of 10,000 square feet for the extension of its present factory.

THE BRITISH THOMSON-HOUSTON COMPANY, LTD., announces the retirement recently of Mr. D. J. Strutt, its commercial engineering representative in the Midlands.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY states that Mr. C. E. Collins has been appointed assistant works superintendent, chief mechanical engineer's department, Earlestown Works.

MONSIEUR PIERRE DE MALGLAIVE, chairman of the Compagnie Générale Transatlantique, Ltd., has been promoted to the rank of Officier of the Legion of Honour for outstanding service rendered to France.

MR. W. V. HODGSON has resigned from the boards of B.S.A. Tools, Ltd., and Burton, Griffiths and Co., Ltd., and has been appointed London area manager of A. C. Wickman, Ltd., in succession to Mr. J. M. Morris.

MR. L. G. REID has relinquished his appointment as managing director of General Aircraft, Ltd., and has resigned from the board of its associated companies. Mr. H. V. Gort has been appointed principal executive director of General Aircraft, Ltd.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION announces that Mr. S. S. Carlisle has been appointed head of the Instrument Section, in succession to Mr. W. C. Fahie, who has resigned to take up an appointment in the Ministry of Defence.

THE PHOSPHOR BRONZE COMPANY, Ltd. announces that its directorate is now as follows:—Mr. J. L. Hardy, chairman; Mr. G. T. Hyslop and Mr. W. Smithson, joint managing directors; Mr. C. V. McNeill, Mr. E. H. Powis, Mr. D. L. Roome, Mr. F. R. Wix, and Mr. A. N. Wormleighton.

HEENAN AND FROUDE, Ltd., announces that Mr. W. M. Ratcliffe has relinquished his position as managing director on account of ill-health. He will continue as joint managing director with Mr. F. J. Fielding. Mr. A. H. Langford and Mr. R. V. Rowles have been elected directors of the company.

THE MINISTER OF TRANSPORT has appointed Mr. J. Jarvie to be Engineer Surveyor-in-Chief and Inspector of Testing Establishments for anchors and chain cables, in succession to Mr. H. Cranwell, who has retired. Mr. Jarvie has been succeeded as Deputy Engineer Surveyor-in-Chief by Mr. F. J. Colvill.

THE COLONIAL OFFICE announces the following appointments: Captain J. M. MacDonald, mechanical engineer, Public Works Department of Nigeria; Mr. N. E. Rose, executive engineer, Public Works Department, Tanganyika, and Mr. W. F. Bolton, engineer transport officer in the Gold Coast.

JOHN BROWN AND CO., LTD., has set up a gas turbine department at Clydebank for the development of the John Brown Escher Wyss closed-cycle gas turbine, particularly for application to ship propulsion. Mr. J. B. Bucher is in charge of the department and Mr. P. McGregor Ross has recently joined the staff.

ENFIELD CABLES, LTD., announces the following appointments: Mr. C. J. Armstrong, A.M.I.E.E., associate director of development Mr. S. G Holmes, associate director of export; Mr. H. D Parsons, associate director of home sales; and Mr. C. J. Sims, works manager of No. 4 works, West Road, Northumberland Park, N.17.

DORMAN LONG AND CO., LTD., announces that Mr. F. L. Smith has been appointed chief technical engineer in charge of the central engineering department and Mr. H. C. Cronk, chief engineer of the plant construction department. A drawing office for both departments has been established in the building formerly occupied by the Middlesbrough Exchange.

DAVID BROWN AND SONS (HUDDERSFIELD), Ltd., announces that Mr. David Brown has recently acquired the whole of the share capital of Aston Martin, Ltd., the activities of which company will be continued at Feltham, Middlesex. Mr. Brown will serve as chairman and managing director, and Mr. R. G. Sutherland and Mr. C. Hill remain technical directors.

A Seven-Day Journal

Exhibition of Radio Components

THE trade exhibition of radio, telecommunications and television components, which was held in London from March 10th to 13th, provided fresh evidence of the prominent part that can be played by one of the newer industries in increasing Britain's exports. The exhibition, organised by the Radio Component Manufacturers' Federation, was on a more ambitious scale than any of its predecessors. Most of the exhibits were for export only and served to demonstrate to buyers from overseas the contribution made to radio engineering by scientific resourcefulness and skilled workmanship. Interesting developments in the industry's raw materials were typified in the displays of modern magnetic alloys, dielectrics and specimens of the new hermetic sealing technique employing metallised ceramics and glass. Components made from some of these new materials were exhibited. Equipment designed for use in communications on centimetric wavebands included cables, wave guides and fittings, together with examples of test apparatus and measuring instruments. There was an extensive range of components intended for special applications: small components designed for "aural-aid" apparatus, a great variety of equipment for installation in ships and in aircraft, and representative examples in the ever-growing category of electro-medical apparatus.

Conference on Productive Efficiency

A CONFERENCE on national productive efficiency, arranged by the Wolverhampton section of the Institution of Production Engineers, took place at Wolverhampton on Saturday last, March 8th. After an official welcome had been extended to the delegates by the Mayor of Wolverhampton, the conference was addressed by Sir Godfrey Ince, Permanent Secretary to the Ministry of Labour, who spoke on the subject of the country's manpower budget. He said that on the production engineers there rested a greater responsibility than on any branch of management in the country. Later, the conference divided into groups to consider the subjects of manpower, management and plant. In the first of these groups a paper on "Training for Efficient Production" was presented by Mr. J. W. Berry, who urged that the training of the efficient production engineer should be visualised as a whole, and that there should be throughout the training a partnership between industry and those responsible for education. The practical side of the training, Mr. Berry said, must of necessity be arranged around the occupation of the trainee. It was equally important that the technical side should be framed around the ultimate occupation of the trainee and not a disconnected, highly academic, pot-hunting scheme of training. Mr. Berry thought that education authorities must be forced to acknowledge that subjects allied to occupation were of equal importance with the higher academic subjects which had hitherto been held to be essential before vocational training had been given.

Institution of Production Engineers

A DINNER to celebrate the Silver Jubilee of the Institution of Production Engineers was held at the Connaught Rooms, London, on Tuesday evening, March 11th, and was attended by a very large company of members and guests. The President, Mr. N. Rowbotham, was in the chair, and the principal speaker was Sir David Maxwell Fyfe, K.C., M.P., who proposed the toast of "The Institution of Production Engineers." Sir David first of all congratulated the Institution upon its growth to a present membership of 7000 from the 244 who came together after the 1914–18 war to pool the knowledge and experience in production engineering which they had gathered during those years. He then went on to discuss the responsibilities which rested upon the Government and upon industry in solving the many problems of the present, and emphasised that the country's ills could only be cured by the old-fashioned remedies of work, knowledge and leadership. A change of ownership of industry, he said, would not solve the problems of industry. Sir David congratulated the Institution upon the work it was doing in the field of technical education. Knowledge was the mother of invention, and the Institution was performing a great service by providing a platform for the expert to give his contribution to the solution of the problems of the day. After a response by the President, the toast of "The Guests" was proposed by Lord Sempill, a Past-President of the Institution, who commented that production engineering was based upon art and science. An important fact to be borne in mind, however, was that there should be a right spirit motivating industry. Response to the toast was made by Mr. O. V. S. Bulleid, President of the Institution of Mechanical Engineers.

Powell Duffryn Technical Services, Ltd.

IT was announced on Monday last, March 10th, that the Powell Duffryn Group has formed a new company, known as Powell Duffryn Technical Services, Ltd., having at its head Mr. Robert Foot, managing director of the Group, and until recently Chairman of the Mining Association of Great Britain. The Powell Duffryn Group was, until January 1st last, the largest colliery undertaking in the world, producing 10 million tons of coal a year. It comprised also many associated companies and used in its own works no less than 500,000 tons of coal yearly. Although the mines have now been transferred to the National Coal Board, the Powell Duffryn Group has retained its world-wide exporting, marketing and bunkering interests. It retains also its existing service organisation for promoting efficient fuel utilisation, which is capable of expansion. This experience and knowledge will now be placed at the disposal of industry in general. The immediate aims of the new organisation may be summarised as follows :—To place at the disposal of industrial undertakings a highly qualified and impartial advisory and consultant service to deal with the efficient and economical use of all types of fuel for all industrial purposes and processes, including the problems of heat, steam and power utilisation in the individual factory; to investigate and advise on desirable changes and the economies to be thereby achieved; to arrange and supervise the installation of new plant for this purpose and, in short, to see the job through from beginning to end; and to act as consultants on any aspect of mining, particularly coal mining, anywhere in the world.

Proposed Institute of Navigation

DISCUSSIONS have been taking place for some time between practical navigators, scientists and manufacturers of navigational instruments on the formation of an Institute of Navigation, and as a result the inaugural meeting of the proposed organisation was held at Lloyd's Register of Shipping in London on Wednesday, March 12, 1947. The meeting was under the chairmanship of Captain G. C. Saul, of the Honourable Company of Master Mariners. The objects of the Institute will be to promote the knowledge and practice of the science of navigation. For many centuries the prosperity of Great Britain has been influenced by our success in solving navigational problems. An Institute of Navigation, which will bring together all the diverse organisations and individuals—the user, the scientist and the manufacturer—concerned with the advancement of this science, should, it is claimed, be of great national value. During the past few years considerable progress has been made in many branches of navigation. All are the outcome of the unprecedented co-operation between instrument makers, scientists and navigators during the war. The plan now is to get in peace the maximum value of the wartime spirit. A representative Steering Committee has been appointed. The initial address of the Institute of Navigation will be care of the Royal Geographical Society, 1, Kensington Gore, London, S.W.7, where further details may be obtained from the Secretary.

Future of the Scientific Instrument Industry

IN the course of an address given by Mr. John Wilmot, the Minister of Supply, at the luncheon held by the Scientific Instrument Manufacturers' Association on March 6th, at the Waldorf Hotel, London, he said that the Ministry was giving special attention to the industry. Under the personal guidance of General Wrisberg, the Controller of Munitions Supplies, surveys were being made of each section of industry so that a clear picture of its structure, its problems and its plans for development could be obtained. By this means it was hoped to get a sound and comprehensive view of the capacity of the industry—present and planned—in relation to the demands that will be made upon it and the opportunities that lie ahead of it. As a result the Ministry would be able to determine how best it could help to fill the gaps in our industrial armoury, to make ourselves less dependent in certain fields on overseas sources of supply and to maintain and develop a self-supporting, progressive and flourishing instrument industry. It was desirable that we should reduce or eliminate the need for importing instruments and similar apparatus, which before the war were brought in at the rate of £2,000,000 a year from abroad. If British production failed to deliver the goods we could not shut out these essential products.

The Late Mr. Henry Greenly

WE regret to have to record the death of Mr. Henry Greenly, which occurred on March 4th at his home at Heston, Middlesex. Mr. Greenly, who was seventy years old, was well known as a consulting engineer and as the author of several books on model engineering. He began his career in the engineer's department of the Metropolitan Railway, and then, in 1901, became assistant editor of *The Model Engineer*. Mr. Greenly severed his direct connection with that journal in 1906 to take up consulting work, specialising in model subjects, and for many years he collaborated with Mr. W. J. Bassett-Lowke in the preparation of locomotive designs for miniature railways in this country and abroad. About this time he started a monthly magazine devoted to models, railways and locomotives, which, however, ceased publication in 1916 owing to war conditions. In the 1914–18 war Mr. Greenly took up an appointment at the Royal Aircraft Establishment, Farnborough, and was responsible for the invention of a flash eliminator for aircraft machine guns. He also took a prominent part in the formation of the "Trade Lads' School" at Farnborough, in which many hundreds of apprentices were trained. From 1919 Mr. Greenly was associated with a number of companies engaged in the production of model locomotives and railways, and in 1922 he became engineer to the Ravenglass and Eskdale Light Railway, which, under his guidance, was converted to 15in gauge. Mr. Greenly will also be remembered for his outstanding work on the Romney, Hythe and Dymchurch Light Railway. He was associated with this undertaking from its inception in 1926 until its completion in 1930, and was responsible for all the civil engineering work, as well as for the design of the locomotives and rolling stock. In 1930 Mr. Greenly reverted to his consulting work, but nevertheless found time to continue his interesting contributions to model engineering journals.

Lord Kelvin and the Diesel Engine

(Contributed)

No. II—*(Continued from page 187, March 7th)*

WHAT has been generally overlooked is that seven years before the date of Lord Kelvin's report on the Diesel patent, the British inventor, Akroyd Stuart, while making researches on actual engines in his works at Bletchley, had arrived at the compression ignition engine. At the time this idea dawned on him, Akroyd Stuart was experimenting on the stratification of gases in internal combustion engines and found that his greatest difficulty arose from pre-ignitions. He did not arrive at the solution of this trouble by any theoretical considerations, though in addition to being a sound, practical engineer he had worked as a demonstrator in the heat-engines laboratory at Finsbury Technical College. What bothered Akroyd Stuart was the practical difficulty of avoiding pre-ignition when compressing an inflammable charge. This difficulty he removed by first filling the engine cylinder, on the suction stroke of the piston, with clean atmospheric air and then heating what he realised to be an excess charge of air by compressing it into the vaporiser or combustion chamber.. At the end of the compression stroke the fuel was injected into the hot compressed air. Operating on this cycle, ignition was effected without pre-ignition, and it was found that not only light-oil spray but heavy-oil spray could thus be ignited. There was no longer any need for an external source of ignition and the explosion was at practically constant volume.

At the time he hit on this brilliant solution, Akroyd Stuart was well aware of the possibility of obtaining power, in an internal combustion engine, from heavy oil. He had been working on this since 1885 and, indeed, the practicability of the petroleum engine had already been successfully demonstrated by Priestman and others. It is, however, the peculiar distinction of Akroyd Stuart that he was the first to propose the cycle of operations which has now become virtually standard on engines burning heavy oil.

Professor William Robinson has related how, before Akroyd Stuart's complete specifications were drafted, the provisional specifications were submitted to Mr. Fletcher Moulton (later Lord Moulton). It was then agreed that the description of the automatic compression ignition cycle was very clear and covered all working compression pressures up to 5000 lb per square inch, or to "whatever practical experience in working indicated." Akroyd Stuart was advised—by Mr. Fletcher Moulton and the Patent Agent—to disclaim, in the complete specification of the compression ignition engine patent (No. 7146/1890) the vaporiser with contracted neck, but to include it in the subject matter of his Patent No. 15,994/1890. He was, however, "at liberty to use that or any other construction of combustion chamber or vaporiser with Akroyd engines working according to your Patent No. 7146 of 1890. The engine cycle is your own invention, and we point out this for your guidance."

The two Akroyd patents expired in 1904, during which year, as it happens, there appeared the first diesel engines built in Great Britain for industrial service. They were constructed from German design by the Mirrlees Watson Company, Glasgow, and a great deal of work was involved in rendering them satisfactory. This work resulted, however, in vital improvements in the injection air compressor. The fact that the first British-built diesel engine constructed for commercial service was not delivered until twelve years after the date of Diesels patent and seven years after the date of Lord Kelvin's report emphasises the extent of the effort called for in translating the original "process" into a practical machine. The first diesel engine delivered from Augsburg (the "Erster abgelieferter Dieselmotor") was installed at Kempten, Bavaria, in 1898, and much difficulty was experienced with this engine prior to its delivery and long after its installation. The changes and adjustments on the Kempten engine were made by Lauster. It was not until about 1907 (the year in which Lord Kelvin died) that the manufacture of the diesel engine began on any commercial scale. By that time the original patent had expired (1906).

Comparison of Akroyd Direct-Injection Engine and Diesel Air-Injection Engine

	1892	1897
Year of test ...		
Engine	Akroyd (mechanical injection)	Diesel (air injection)
Number of cylinders ...	one	one
Arrangement ...	horizontal, with trunk piston	vertical, with crosshead
B.h.p.	14	19·87 (metric)
B.m.e.p.	68 lb per sq in	76·7 lb per sq in
B.m.e.p.	4·78 kg per sq cm	5·39 kg per sq cm
Bore and stroke (inches)	8¼ by 12	9·84 by 15·74
Bore and stroke (mm)	215·89 by 304·79	250·35 by 398·5
Stroke : bore ratio	1·4 : 1	1·6 : 1
Speed	240 r.p.m.	171·8 r.p.m.
Revolutions per second	4	2·86
Ignitions per second	2	1·43
Injection period (approximate)	0·025 sec	0·025 sec
Cooling interval per ignition ...	0·5 sec	0·7 sec
Piston speed ...	480·0ft per min	450·68ft per min

NOTES.—The particulars of the Akroyd engine are from MS. records by T. H. Barton, O.B.E., on brake tests made by him in February, 1892, on a direct-injection Akroyd compression-ignition petroleum engine, operating without heated vaporiser and with compression pressure high enough to ensure auto-ignition of heavy oil.

The particulars of the diesel engine are taken from "Diesels rationeller Wärmemotor," Professor M. Schröter, Z.d. Vereines deutscher Ingenieure, No. 30, Band XXXXI, July, 1897.

The only feature of the Diesel "process" which had real utility was the high compression pressure. It was by reason of this feature that the engine was able to burn heavy oil. Dugald Clerk, speaking in 1912, pointed out that the Diesel type of engine offered no special economy from a thermodynamic point of view. "The great advantage of the Diesel type (he said) did not lie in that but in its capacity to burn crude oils." He could not have been aware that as early as 1892–1893, Akroyd Stuart, adopting a suggestion made by his friend, Professor William Robinson, had actually burned palm oil in the Akroyd engine. In doing this he heated the oil by passing it through the vaporiser jacket thus rendering it less viscous prior to injection. At the same time he adopted the ingenious expedient of injecting a lighter oil as a pilot ignition charge, separate injection pumps being used. This pilot injection system was subsequently patented by Akroyd Stuart.

No one having any knowledge of internal combustion engine patents from Barnett's of 1838 onwards can suppose that there was any creative step in increasing the compression pressure. This is well shown in Fairweather's report mentioned above. It has, however, been asserted that, irrespective of whether the high compression pressure did or did not constitute patentable subject matter, the diesel engine was the first heavy-oil motor in which the heat necessary for securing auto-ignition was obtained solely by compression, the air being raised to a temperature higher than the spontaneous ignition temperature of the fuel. This impression has been corrected by the late Mr. T. H. Barton, O.B.E., who, during the early part of 1892, removed the vaporiser from an Akroyd compression ignition engine, substituted a flat wrought iron cylinder head, into which was fitted a water-cooled fuel-injecting nozzle and increased the compression pressure by fitting an oak block between the foot of the connecting rod and the big end bearing. The direct-injection engine thus arrived at was, after being started with much difficulty, run on load for six hours without any extraneous igniting or heating device. It was, of course, emphatically a case of letting the combustion "do what it liked," and Mr. Barton has recorded that there was a heavy ignition "knock," so heavy that the experiment was interrupted by Mr Robert Edwards before fuel consumption measurements were taken. The particulars of the direct-injection Akroyd engine thus brake-tested at Grantham in the spring of 1892 and of the air-injection diesel engine tested at Augsburg in the spring of 1897 are shown in the tabular statement on this page.

As illustrating the development of injection equipment it may be noted that whereas in the original experimental Akroyd direct-injection engine the approximate injection period was 0·025 seconds, the injection period of the modern high-speed oil engine is approximately 0·0012 seconds. The rate of injection has risen from, say, 2 per second in the early slow-speed four-cycle Akroyd engine to about 13 per second in the modern four-cycle high-speed engine. The development in speed has marched in step with the development in injection equipment. It was, indeed, the lack of efficient and durable injection equipment which hampered the development of the Akroyd engine in its compression-ignition form. As soon as the mechanical injection equipment reached a sufficiently high level of efficiency and durability the air-injection rapidly lost ground. It is true, nevertheless, that the use of air-injection continued for long after the expiry of the Diesel patent and a large number of engines so equipped is still giving excellent service.

Mr. Charles Day has, among other interesting papers, come upon records of the tests made at Augsburg prior to the tests certified on February 17, 1897, by Professor Max Schröter, Herr Brueckner and Dr. Munckert, all of the Technical High School at Munich. Apart from such unpublished factory tests as may have been made on the final experimental engine, the first series of official tests appears to have been taken on February 1, 1897. The duration of those tests is not shown on the copy of the record, but it is mentioned that there were present, along with Diesel and the engineers of the Maschinenfabrik Augsburg (Vogel, Reichenbach and Lauster), Mr. Fred Dyckhoff of Bar-le-Duc. An interesting piece of information is that

on the same day (February 1, 1897) tests were made on a Deutz petroleum engine of practically the same swept volume and of identical piston speed as that of the diesel motor. The fuel consumption of the Deutz engine at full load was at the rate of 383 grammes per b.h.p. per hour, which compares with 244 grammes in the case of the diesel engine. The Deutz engine, however, could not be run for more than about twenty minutes owing to excessive temperature.

There was a second series of official demonstration tests on February 4, 1897, made in the presence of Direktor Schumm and Herr Stein of Gasmotorenfabrik Deutz and Ober-Ingenieur Gilhausen of Fried. Krupp, Essen. The full load fuel consumption was certified as at the rate of 238·0 grammes per b.h.p. per hour.

A third series of demonstration tests took place on February 12, 1897, these being made in the presence of Mr. F. Sulzer-Imhoff, Mr. Carl Sulzer-Schmidt and Mr. Eric Brown, all of Messrs. Sulzer Brothers, Winterthur. These tests showed results comparable with those obtained previously and they were followed, five days later, by the tests made by Professor Schröter. It is to be noted that the tests which are referred to in Lord Kelvin's report are those made at Augsburg on February 1, 1897. The typewritten copy refers to other tests made at Augsburg on October 24, 1898. This must be an error in typing, since the report is dated from the University of Glasgow, March 31, 1897.

All the tests appear to have been made with American lamp oil, from a store in Augsburg, of specific gravity ranging from 0·786 to 0·800, with calorific value ranging from 9927 Cal./kg to 10,250 Cal./kg.

Mr. Charles Day has also brought to light an interesting letter addressed by Mr. Ludwig Nobel, St. Petersburg, to the M.A.N., Augsburg. This letter is dated (St. Petersburg) February 15, 1899, and refers to a 30 h.p. Augsburg-built diesel motor which was delivered to Nobel's in December, 1898. This engine had, when the letter was written, been in operation for three weeks and had functioned in such a way that Mr. Nobel expresses his "complete satisfaction." He mentions that the cylinder was lubricated with a special Nobel lubricating oil of "viscosin flash point 310," and that the engine was running on raw Baku naphtha of sp. gr. 0·877, the fuel having been in store for a whole year. When running light, the combustion was defective and Mr. Nobel thought he could overcome this defect by increasing the compression. He found, however, that what was required was not an increase but a decrease of the compression, and he fitted a small throttle valve on the air suction pipe by means of which the compression could be reduced from 32 atmos. to 28 atmos. At this reduced compression the smallest charges of naphtha could be burned with regularity.

Mr. Nobel's comment is as follows: "The explanation of this circumstance I see in the fact that the volumetric proportion between naphtha and air has an important bearing upon the combustibility of the compound, in so far as if air is present in great excess, the compound, even with a high temperature, is difficult to ignite, and small charges of naphtha require smaller quantities of air to render them combustible . . . the compound is proportionately richer in naphtha and therefore more readily ignited." Mr. Nobel adds the further practical suggestion that "when working the diesel motor with raw naphtha that fact must not be neglected that the naphtha contains a fine, sandy dust which in time might injure the motor. To prevent this it is necessary to filter the naphtha well, and I am of opinion that a naphtha storage tank with a good filter should be supplied by the manufacturers for every motor which is to be worked with naphtha."

In conclusion, the more one studies the early history of the heavy-oil engine the more does one become of the opinion expressed by Professor William Robinson that the diesel engine was not so much an invention as a machine evolved by the engineers of the Maschinenfabrik Augsburg. Moreover, there never was a machine the birth and infancy of which brought together so great a concourse of mechanical engineers, physicists, professors, commercial directors and bankers. When contemplating, on the other hand, the poverty of the resources at the disposal of Akroyd Stuart, we may well marvel that within a single year he had not only enunciated the fundamental ideas of the compression-ignition engine and of the pre-combustion chamber with contracted transfer passage, but that within six months from the date of his patent, actual engines were at work in his showroom at Finsbury, London. Accomplishments of this kind are, indeed, the very glory of British technical achievement and Akroyd Stuart is in the succession of such men as Newcomen, Barber, Trevithick, Symington, Murdock, Brown, Stephenson, Barnett and many others whose intuitions have proved of world-historic importance.

Apart altogether from any question as to the originality of the Diesel patent, it remains true that the evolution and manufacture of the diesel engine had a more powerful effect on the progress of the heavy-oil engine than any other event in its history. Great ingenuity was exercised and vast expense incurred in the effort—put forward by the engineers of all countries in which licences were granted—to translate the theoretical ideas of the patentee into a machine which would work. It is also true that the tests made at Augsburg in 1897 disclosed a performance, in respect of fuel economy, which was far in advance of anything previously recorded.

To-day, however, the characteristic features of regulated combustion and blast-air injection have become obsolete and the modern heavy-oil engine is of the type originated by Akroyd Stuart, that is, the automatic-ignition engine in which the fuel, added by mechanical injection at the end of compression, is allowed "to do what it likes." While the description "Diesel" as applied to an air-blast injection heavy-oil engine does ample justice to Diesel, it is a monstrous injustice to other inventors and an absurdity beyond laughter that on the supersession of the Diesel "process" the name "Diesel" should be adopted as descriptive of a machine which was in existence before the date of Diesel's patent. One effect is to inculcate the ridiculous notion that the heavy-oil engine, as we now know it, is a German invention. On the contrary, the modern heavy-oil engine is predominantly a British invention and is more accurately described as an "Akroyd" than as a "Diesel" engine. It should, however, in justice to the many engineers of all nations who have laboured on its development and refinement, be called an "Oil Engine," thus taking its place with the internationally-named steam engine, steam turbine and gas turbine. Engineering science knows no frontiers and it is incumbent on all engineers to render credit where it is due.

Locomotive Power at Speed

THE INSTITUTION OF MECHANICAL ENGINEERS

No. II—(*Continued from page 201, March 7th*)

MR. H. Holcroft remarked that the subject of the paper was but one part of the many-sided problem of the locomotive. The parts were so interrelated that to consider one without the others overlooked this interdependence; and he had a feeling that the author, to use a topical expression, had tended to adopt the "closed shop" attitude in excluding a number of problems. For instance, improved boiler and superheater design and improved smokebox arrangements would result in the easier passage of gases, and therefore with a reduced velocity at the exhaust tip; and that meant that there was lower back pressure in the cylinders, and therefore the cylinders had greater capacity and efficiency.

That was one point which the author had not taken into account. The author had assumed a back pressure of 20 lb absolute in all his calculations, and that was notwithstanding the fact that in American practice the back pressures were very much higher than were reached in British practice. The adoption of 250 r.p.m. to 400 r.p.m. in itself raised a whole crop of problems. For instance, in raising the revolutions from 200 to 400 the hammer-blow in two-cylinder engines was increased four-fold.

He thought that in some way or other the author should include the question of stroke in his calculations. It brought in piston speed, and it was some measure of how much steam could get in. The author's adoption of revolutions as the basis of his curves held good to the extent that any variation of piston stroke from the average was covered by his general coefficient k, which absorbed all the idiosyncrasies of any particular locomotive, including stroke and back pressure, and that was quite safe in developing a formula for mean effective pressure at various cut-offs in the locomotive in question; but to apply the same coefficient to new design seemed rather a risk, in that it did not include this question of stroke or back pressure.

Boiler Working Pressure

Dr. W. A. Tuplin, after congratulating the author on presenting a paper which was full of interesting information, said Fig. 6 was of particular interest to him. From that figure it would be seen that while the steam pressure varied from 140 lb to 280 lb per square inch the rate of steam consumption varied very little indeed. Actually it varied rather less than that diagram suggested, because the origin was not on the diagram at all, but twelve divisions below. The variation of steam consumption with steam pressure was therefore very low indeed, so that there was not much gain in efficiency by raising the pressure. The diagram was based on 650 deg. Fah., so that the steam rate was proportional to the coal rate.

Since the efficiency was not appreciably improved by raising the pressure, he had

wondered why there had been a tendency to raise the pressure. It was true that it meant that the cylinders could be reduced in size, but that seemed to him to be a very small advantage to set against the greater weight of the boiler, which meant that unless the higher pressure meant higher efficiency, which was not proved, the power-weight ratio of the locomotive went down as the pressure went up.

It was disappointing to a designer to adopt higher pressures and find that the coal consumption did not go down. One could get a coal consumption of about 3 lb per d.b.h.p.-hour, and the scatter round that figure seemed to be almost independent of pressure. Whether the designer made a mistake in his thermodynamics or not, the engine never did. Steam had fleeting opportunities of getting into the cylinder through a very narrow opening, and its success in getting in depended on how quick it was off the mark. It was astounding to realise that working at one constant temperature, 600 deg. Fah., the energy in a pound of steam was hardly different at 10 lb per square inch, from what it was at 300 lb per square inch, and if anything it was slightly less at the higher pressure, so that high-pressure steam did not move any faster and was not quicker at getting in. One could work out the velocity of propagation of a wave through steam, which was proportional to the square root of the absolute temperature and was independent of pressure. It was possible to get the steam moving faster by raising the superheat, but the advantage was small, so that superheat was not worth bothering about very much.

He did not wish to be misunderstood. If one took an engine designed for 200 lb per square inch and put a 300 lb per square inch boiler on, of course, she would jump away almost as if jet propelled, provided she did not slip, and once she got going, as long as she held together, she would go along the track in an abandoned fashion. It would probably be found that the coal consumption came down; the tractive effort had gone up, it was possible to work at a lower cut-off, and therefore the efficiency was higher. But that result could be obtained without increasing the boiler pressure, simply by increasing the cylinder pressure.

Summarising, to get a high ratio of mean effective pressure to steam chest pressure it was necessary to have a high ratio of area of port opening to cylinder volume. Secondly, to save coal it was necessary to have a high expansion ratio and no leakage. Thirdly, to save water it was necessary to have a high superheat and no leakage. Fourthly, to secure a high power-weight ratio one needed the lowest practicable boiler pressure and no leakage. Finally, if one wanted leakage one might go in for high pressure.

Mr. O. S. Nock referred to one factor which was not mentioned in the paper, and which he did not know whether the author had taken into account, namely, superheat temperature. He imagined that an engine in which the degree of superheat was lower than in the case of, for example, the L.M.S. converted "Royal Scot" would not show such good figures, even though the cylinder dimensions were the same and the cylinder proportions generally—ports and so on—were just as good.

His next points suggested that the whole engine had to be considered rather than one portion of it, and how important it was in analysing locomotive performance to take each little piece by itself rather than treating the whole thing on the basis of the draw-bar horsepower. One might have quite a good cylinder performance and a poor boiler and would get very poor draw-bar horsepower figures in consequence.

He had often wondered whether tests had ever been carried out to find out exactly what the difference in coal consumption was between running an engine with, say, a wide-open regulator and 10 per cent cut-off and running at, say, 30 per cent cut-off and the regulator opened just wide enough to maintain the scheduled speed. It would be interesting to see exactly what the difference was.

Trial Application of Author's Methods

Mr. J. L. Wilson, dealing with the use of the author's basic data curves as a criterion for assessing the performance of an existing locomotive in respect of power developed, said from footplate trips he had noted certain results to which he had tried to apply the author's method of analysis. On the L.N.E.R. between Newark and milepost 127 the track was almost level, and with an "A4 Pacific" and 530 tons load a steady speed of 64 m.p.h. was reached, which, taking resistance curves and estimating the draw-bar pull, would require a draw-bar pull, to maintain that speed, of 7000 lb. The observed conditions from the footplate were 160 lb per square inch steam chest pressure at 17 per cent cut-off, which, applying the author's curves and the speed correction factor, the $\sqrt{N}$ factor, gave a mean effective pressure of 35·7 lb per square inch, which gave a tractive effort of only 5900 lb. He could not find the reason for the discrepancy between a tractive effort of 5900 lb and a required draw-bar pull of 7000 lb. He found the same discrepancy for the next section, for level track with a constant speed of 60 m.p.h.

If cut-offs were increased by 25 per cent, theoretically one would get back to about the correct answer, and one got that over quite a large range of speeds which he had examined. It seemed to him that either the speed correction factor, $\sqrt{N}$, was wrong somewhere, or that the value derived from the basic data curves which was multiplied into the speed correction factor had to be derived in some other way than just observing the conditions on the engine.

He did not think that the boiler pressure had anything to do with the output of a locomotive in these days; full boiler pressure was rarely used in the operating range between 40 and 60 m.p.h.

Mr. D. R. Carling said that the whole of the author's thesis was really devoted to establishing a criterion for the measurement, on a consistent basis, of the extent to which any locomotive maintained its theoretical output with rising speed, and also by which one locomotive might be compared with another. The basis, however, was not a fixed one; there was a different criterion for each different boiler pressure, as a start. In other words, the author was not providing a strict measure of one locomotive against another, but rather of the relative effectiveness of one locomotive's steam circuit and distribution against those of another, making allowance for the possible difference of initial pressure of the working fluid.

Again, the actual standard of comparison was also varied according to one particular feature of the steam circuit, the clearance volume; but it was surely wrong in principle to provide a standard which varied according to the measure of one part of the article which was to be compared to that standard. After all, the amount of the clearance volume was as much a part of the design of the steam passages as the number and size of the superheater elements or the diameter of the blast pipe, or even the characteristics of the valve gear; indeed, it was most intimately bound up with certain features of the valves and valve gear. That did not mean that the factor k was not of value—far from it—but it did mean that it was necessary to think very clearly just what k really was, before using it as a means of comparison.

The author had criticised some formulæ for locomotive power which were based on boiler dimensions and assumed an engine of good current design, but was that fundamentally any less correct than basing the power on the dimensions of the engine and assuming that a boiler of good current design would provide the necessary steam? A more accurate knowledge of the rate of steam consumption might make it possible to know more accurately what power to expect from a given rate of steam production, but the upper limit would still be fixed by the boiler's ability to produce the necessary steam.

There was a possible reason for the high power output of some locomotives fitted with poppet valves at high speed. Most poppet valves were returned to the closed position by springs or by steam pressure and, should there be even a minute delay in closure, the nominal cut-off would be increased. If the nominal cut-off was very early and speed very high, the effect of delay in closure of the inlet valve would be very marked, while delay in closure of the exhaust valve might also make the indicator diagrams fatter.

Mr. E. L. Diamond, in reply, deprecated the idea that he had proposed in any way a new standard cycle. The theoretical indicator diagrams which he had used, he said, were merely diagrams calculated in accordance with classic thermodynamic theory; and, so far from having used them as a standard, he had in the curves of relative efficiency in the first section of the paper compared them with the Rankine cycle, which he was conservative enough still to use as a standard.

Secondly, he hoped it would be clear that he was not attempting to suggest for one moment that his method of calculating horsepower replaced those methods of determining maximum locomotive capacity in which the boiler had to be taken into account. The whole point was that for the most economical working of a locomotive at speed it was necessary to work it with a better expansion ratio than would normally be used in order to exhaust the boiler; otherwise the locomotive was not correctly designed. For the purpose of calculating train schedules and for other calculations it was more valuable to have some means of determining what the power would be at a particular cut-off which had been predetermined as the correct cut-off to work that engine at that speed, rather than to know as a matter of interest what the engine could do if one tried to boost it to the utmost possible extent.

He thought that perhaps the diagram should be plotted on the basis of piston speed rather than r.p.m. He had perhaps been a little hasty about that. It arose from the fact that the stroke in most modern locomotives was very much the same.

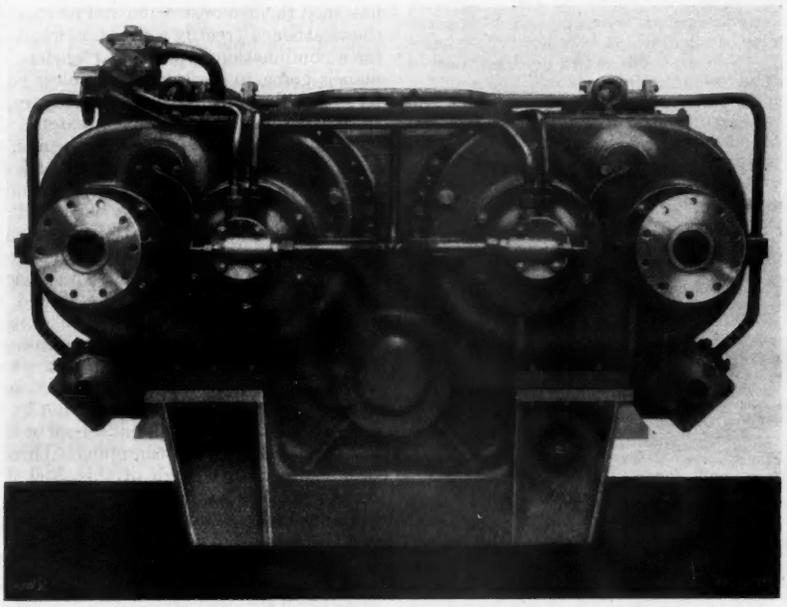
Generation of Electricity, January, 1947.—The official returns rendered to the Electricity Commissioners show that 4671 million units of electricity were generated by authorised undertakers in Great Britain during the month of January, 1947, as compared with the revised figure of 4142 million units in the corresponding month of 1946, representing an increase of 529 million units, or 12·8 per cent. The total number of units sent out from the generating stations of authorised undertakers during that month (*i.e.*, units generated less units consumed in the stations by auxiliary plant and for lighting, &c.) was 4423 million units, as compared with the revised figure of 3917 million units in the corresponding month of 1946, representing an increase of 506 million units, or 12·9 per cent.

Worshipful Company of Shipwrights' Exhibition

No. V—(*Continued from page 189, March 7th*)

Modern Wheel Drive, Ltd.

OIL-OPERATED S.L.M. reverse-reduction gears were displayed on the stand of Modern Wheel Drive, Ltd., of Lindo Lodge, Chesham, Bucks, and Slough Trading Estate. They included examples of oil-operated reverse reduction gears and oil-operated multi-



TWIN ENGINE REVERSE REDUCTION GEAR—MODERN WHEEL DRIVE, LTD.

engine gears for main propulsion. Before and during the war these S.L.M. oil-operated marine transmission gears were installed in coastal and deep-sea vessels, tugs and trawlers, also in ferry boats, motor torpedo boats and minesweepers. All Admiralty tank-landing craft were fitted with these gears, and other vessels, such as motor torpedo boats, minesweepers and air-sea rescue craft. Some landing craft were equipped with twin engine gear-boxes, enabling two engines to be used to drive a single propeller shaft, an arrangement which provided ahead and astern running and where needed the isolation of the engine from the gearing by the simple movement of a single lever.

In the latest designs, some of which were shown, two or four engines can be coupled by oil-operated multi-engine transmission gears to one propeller shaft. Gears can be designed for powers up to 12,000 b.h.p., the speeds of the engine and propeller shafts being about 400 and 100 respectively. In all these transmission gears, the ahead and astern wheels incorporate an oil-operated coupling. It consists of two inner and two outer members. The two outer members are carried and are free to rotate on the sleeve or hub of the two inner members, which in turn are carried on longitudinal splines on the secondary shaft. The gearing being in constant mesh, the primary shaft causes the outer coupling members to revolve on the sleeve or hub of the inner coupling members, but motion cannot be transmitted to the secondary shaft until the inner members of one or other of the couplings are caused to engage with the inner faces of the outer members of that coupling and until, in fact, the neutral position is abandoned and either the ahead or the astern coupling is brought into engagement. Such engagement is effected by directing oil under pressure into the chamber between the inner members, which then slide axially on their splines until they engage the outer members, where they are maintained in working contact by the oil pressure until it is released.

Disengagement after release of the working oil pressure is ensured by pressure oil also on the opposite face of the inner members, which returns them to their idling position.

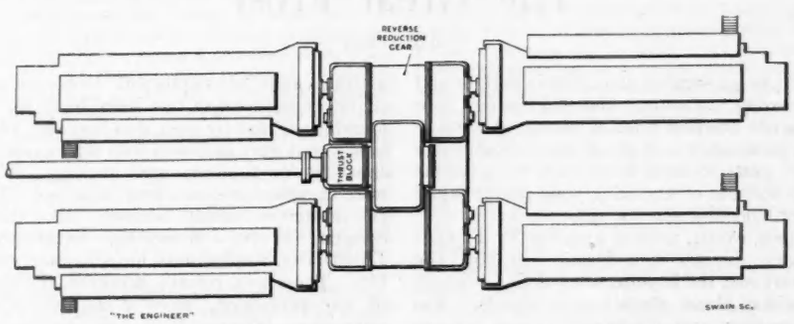
The pressure oil system consists of a pump, a by-pass valve, a control cock and ducts through which the oil passes at the correct volume and pressure to operate the couplings and to lubricate the working surface. All oil-operated couplings are engaged and disengaged by turning the handle of the control cock, which has three positions —ahead, stop and astern. The time taken to operate from full ahead to full astern and *vice versâ* is said to be about two seconds, and there is no possibility of more than one oil-operated coupling being in engagement at one time.

The accompanying illustrations show a twin engine reverse-reduction gear for main propulsion, seen from the forward side, and the arrangement of a multiple-engine main propulsion gear coupled to four engines. Gears of this type are available up to 12,000 b.h.p. driving a single propeller, the engine shaft speed being about 400 r.p.m. and the propeller speed about 100 r.p.m. An oil-operated isolation coupling working on the same principle as the gears already described was also shown.

Vosper Ltd.

A prominent model on the stand of Vosper Ltd., of Portsmouth, was that of a "1944" class motor torpedo boat, shown in the engraving herewith. The hull is constructed in wood, according to the firm's latest designs, and the bridge is protected by ⅜in. non-magnetic bullet-proof plating. **Controls on the bridge** comprise engine-room telegraph, view plot, torpedo firing lever, instrument panel, steering compass and remote control for the C.S.A. gear. The steering gear is of the Mathway mechanical type, and has an emergency position aft in addition to the bridge position. Armament consists of a 6-pounder gun forward, a 20-mm Oerlikon gun aft, and twin Vickers 0·303 machine guns port and starboard. **There are** also a rocket flare projector and two 18in torpedo tubes. Other equipment includes echo sounding gear, a hydrophone, C.S.A. apparatus and two lifeboats. The propelling machinery consists of three Packard engines, each with a designed output of 1320 b.h.p. at 2400 r.p.m. The designed speed of this boat is in the neighbourhood of 40 knots, **but varies with** the fuel load carried

Other models included one of the motor torpedo boat "No. 102," the prototype of Vosper M.T.B.s built in 1936; also one of the Royal barge built in 1938 for King George VI, which has accompanied him to South Africa. It is a 40ft craft with three Vosper "V.8" engines and has a cruising speed of 24 knots. Finally, there was shown a model of a 73ft Vosper air-sea rescue launch, which is powered with Thornycroft



ARRANGEMENT OF S.L.M. GEARS COUPLED TO FOUR MAIN ENGINES—MODERN WHEEL DRIVE, LTD.

engines and two Vosper "V.8" engines for slow running or cruising purposes. The speed of this launch is about 25 knots.

Other Exhibits

On other stands exhibits included a model of the Denny-Brown stabilising gear, to be fitted on the Southern Railway Company's cross-Channel ship "Falaise," now under construction, which was applied to many naval

ships during the war. The Self-Changing Gear Company, Ltd., of Lithalls Lane, Coventry, showed a transparent working model of its "M.R.F.10C," marine reduction and reverse gear, which, it will be recalled, was fitted on to "Gay Viking" class of high-speed boats designed by Camper and Nicholson, Ltd., of Gosport, which successfully ran the blockade between this country and Sweden many times during the war. On the stand of B. R. Vickers (Leeds) Engineering Company, Ltd., there were exhibited several examples of the firm's "Vista-Neox" oil bath stern tube.

In our first article we mentioned the prizes to be awarded for outstanding exhibits. The awards were announced shortly before the close of the exhibition and the prizes were presented on Friday, February 7th, by Sir Amos Ayre. They included the bronze plaque presented by Sir Amos Ayre, Prime Warden of the Shipwrights' Company for the best model of a vessel under 1000 tons deadweight carrying capacity. This was won by the Rowhedge Ironworks Company, Ltd., of Rowhedge, near Colchester. The bronze plaque presented by the Caledon Shipbuilding and Engineering Company, Ltd., of Dundee, for the best series of models shown by any one firm was won by Swan, Hunter and Wigham Richardson, Ltd., of Wallsend-on-Tyne. A silver cup presented by James Pollock, Sons and Co., Ltd., for the best working model of educational value, either of a ship or marine equipment, or both, was won by Clarke, Chapman and Co., Ltd., of Gateshead, for its excellent model of modern winch operation. The bronze plaque presented by F. T. Everard and Sons, Ltd., for the most interesting model of a vessel not exceeding 230ft in length was won by Henry Robb, Ltd., of Leith; while a bronze plaque presented by Mr. J. A. Billmeir for the best model of a marine engine was won by Wm. Doxford and Sons, Ltd., of Sunderland. This firm showed a large model of a five-cylinder Doxford opposed-piston engine and a full-size set of engine controls. The judges for the competition were appointed, at the invitation of the Exhibition Committee, by the Institution of Naval Architects, the Institute of Marine Engineers and the Honourable Company of Master Mariners.

MOTOR TORPEDO BOAT—VOSPER, LTD.

The Great Frost

(Contributed)

"IF you go buzzing about between right and wrong, vibrating and fluctuating, you come out nowhere; but if you are absolutely and thoroughly and persistently wrong, you must some of these days have the extreme good fortune of knocking your head against a fact, and that sets you right again."

These words, uttered long ago by Thomas Huxley, express in a drastic way both the gloomy and the hopeful sides of the situation in which Great Britain now stands. The "vibrating and fluctuating" has led us nowhere, and we now wake up to the sombre fact that it is only by the hard road that we can survive, let alone prosper. The fight is now recognised as one for survival, and the engineer—who is very rarely a politician—is called upon to do a massive share. Engineers can be pardoned if they use plain language and regard with distrust those "songs in the heart" which are too often offered by politicians in lieu of the rocklike facts of experience. Engineers have, moreover, an ingrained belief that without work and the environment which stimulates the worker, nothing can be accomplished. Moreover, our engineering progress has been built up on foundations laid by men who had very little to say, but were endowed with a phenomenal capacity for thinking and working. They were in most cases men from what are called the lower or middle classes. The Newcomens, Watts, Murdocks, Symingtons, Trevithicks, Stephensons, Faradays and such-like. These men remain, however, the glory of our profession, since it is from their pioneering labours that our engineering industry has developed. If we take note of the conditions under which they worked we will find them very hard conditions; but hard as they were, no fetters were placed on their imagination and their work thrived in an era when control and interference by the State were almost unknown.

We have lived to see an era when the State has sought, by control and interference—disguised as "planned economy"—to strip the citizen of his freedom and deprive the community of the benefits of individual initiative. Initiative does not blossom on the concrete of control, and government by unfettered bureaucracy is government by caterpillars.

The melancholy spectacle of an industrial nation virtually shut down at a time when the demand for its products was unexampled is something new in history. To point, at the same time, to the "social climate" which has been built up is useless and we may recall the words of the German democrat, who remarked—long before the appearance of Hitler—that "Sozialisieren kann man nur wenn die Schornsteinerauchen" ("Socialism is possible only when the (factory) chimneys are smoking"). We have lately witnessed a unique demonstration of the truth of this saying, and it is beside the mark to put the blame on the weather. The weather has but hastened the demonstration and no change in the weather can rectify a situation which calls for a combination of work and wisdom. No man is going to work his best unless he can feel that he will be free from oppression from whatever direction it threatens. Nor is it in human experience that a man will work effectively under conditions which deny him the fruits of his labour.

Our engineering progress is based, not on politicians and legislation, but on inventors and craftsmen, and it has already been remarked that those men who pioneered this progress were craftsmen endowed with an imagination which cannot be exercised unless in conditions of freedom. Speaking for mechanical engineering in particular, we may note that the industry has been built up by men who worked in factories and not by men who wrought in any political school or found their livelihood by tub-thumping. There has been more than enough of this, and if the Arctic weather has assisted to illumine the peril in which we stand, then it will have done what no amount of verbiage and no multiplication of White Papers could have accomplished.

We must continue to live, and this involves upon us all the need of concentrating on work rather than on talk. We should also choose those who govern us—irrespective of party—from those who understand, among other things, the needs of an industrial community and the value of personal initiative. If we do not, if we prefer soft words from those who have "songs in their hearts," without possessing knowledge of the conditions which alone will keep us employed, then we must agree with the great Mr. Selden, that "He that will keep a monkey should pay for the glasses he breaks."

Retirement of Sir Aylmer Firebrace

AT a recent meeting of the London County Council it was announced that Commander Sir Aylmer Firebrace retired on February 28th from the position of Chief of the Fire Staff and Inspector-in-Chief of Fire Services, which he has occupied since the formation of the National Fire Service in 1941. Altogether, Sir Aylmer has rendered nearly twenty-eight years of distinguished service to London's fire-fighting forces. After the 1914–18 war, he retired from the Royal Navy, and in 1919 was appointed principal officer of the London Fire Brigade, becoming deputy chief officer in 1936. On the retirement of Major C. C. B. Morris, Sir Aylmer succeeded to the position of Chief Officer of the London Fire Brigade in 1938, and on the outbreak of war, in 1939, he was seconded to Government service to act as Regional Fire Officer for the London Region. In its reference to Sir Aylmer's retirement, the London County Council recorded high appreciation of the services which he has rendered during his many years of active association with and leadership of the fire-fighting forces of London.

Industrial Research*

As was the the custom at the end of the last century, I served my time in the shops as an engineering craftsman, and having done one or two things between, I found myself on the scientific staff of the National Physical Laboratory. That was in the first year of its career—about 1901. For eighteen years I viewed and criticised industry, and particularly the electrical industry, from the safe shelter of that establishment. An opportunity then came to me in 1919 to break away into industry itself, with a unique chance to put one's ideas to the practical test—the very searching test—of their application to industry. I was to establish an industrial laboratory, where none had existed before, for a group of large electrical factories under Lord Hirst.

The idea of science associated with industry was at that time germinating, and the idea of industrial research was being strongly emphasised by the newly established Department of Scientific and Industrial Research. Notwithstanding the importance and the glamour of the research objective, and without disparaging it, it had always seemed to me that the primary need of most industries was something which could be better described as scientific service—understanding, and helping the factory staff to understand, their own processes and products—to measure and to appraise in a scientific way what goes into the factory, what goes on there, what sort of product comes out of it, and, in a large number of cases, how that product should be used by the community. Do not make the mistake (as I fear some do) of belittling the importance or the scientific difficulty of this work. The great J. J. of Cambridge, who discovered the electron by his searches into the fundamentals of the electric discharge, became associated in later life with the industrial research movement. He used to remark on the great difficulty in which the scientist found himself because in industry he not only had to find a solution to each specific problem, but it had to be correct. If it was not you knew all about it in such a very short time.

This scientific activity within industry is usually talked of as research because (I suppose) it is based on a scientific laboratory. Personally I never mind very much what things are called, provided people are not misled and confused. The experts can often find their way about in the confusion, but the usual fate of the non-expert is (I am afraid) to be hypnotised by half-truths, unless the experts can be induced to be explicit.

I have in mind what amounts to an essential difference of emphasis and procedure. I would like to bring into focus the two aspects of scientific activity in industry, aspects which one finds are frequently confused under the undiscriminating title of industrial research. I think the point is rather important, as our concern for the productivity of industry increases. The research director and his staff, not to mention their principals, will be very much at sea unless they know which aspect is to predominate in their planning. The organisational structure they devise in order to marry their research activities into their industry must match up with its real needs.

One aspect is, I think, the most commonly understood. It is the setting out to discover new products or processes which if adopted will constitute a breakaway from what exists at present. The other aspect is to take as our subject the existing processes, procedures and products of an industry. To seek by scientific study to get behind their empiricisms so that they can be established on a scientific basis. You will at once see the difference—for No. 1 can be carried on in a detached establishment by a staff whose only qualification is scientific research. No. 2 needs, in addition, an organisation which must knit in an intimate way the scientific staff of the research establishment and the technical staffs of the factories, and which will establish a constant interworking between them.

I am not touching upon that well-worn theme of what are fundamental or basal or applied research. It is perhaps unfortunate that the term research has become so respectable that its popularity causes it to be used quite indiscriminately, that a professional scientific man who cannot say he is doing research is regarded as a sort of lower order of life, no matter if he is a teacher, even a Professor, an industrialist or even, maybe, an administrator in a Ministry at Whitehall. So we all try to pretend we are doing research to discover some great new thing when really most of us are, or ought to be, trying to do something rather different.

I may add that those who follow the lowlier and more thorny path of studying to understand industry as it exists, not infrequently, but incidentally, find in it a stimulation to discoveries of the first magnitude, both practical and theoretical. By this means many scientific contributions, many discoveries of real importance have been achieved, as I hope to show, but I just drop this thought: what volume of new discoveries and developments per annum do we consider it possible for industry to exploit? Is it unlimited? My own experience and observation leads me to the conclusion that ordered and efficient industry can reach a condition of indigestion and then of constipation much sooner than we would like to think.

I emphasise all this, not, of course, to disparage the great search for scientific truth for its own sake (that is a different subject altogether) but rather to show that in the industrial field there are two possible roads to the achievement of industrial efficiency and new advances. One direct and the other indirect, and that the primary need of most industries, but not necessarily all of them, is for all those advantages which are implicit in the indirect approach. So when I joined up with industry in 1919 both I and my principals decided to forget for the time being about dreams of new discoveries, and organise for a scientific general staff who were to be based upon a really up-to-date experimental laboratory.

Now one of our earliest needs was found to be some machinery of organisation which would foster a psychological union between the staffs of the factories and that of the laboratories at all levels. This need rested on the principle that if the psychology between staffs is right the rest can largely be left to look after itself. Conversely, that if the psychology is wrong the most brilliant research is apt to be stillborn so far as its application in industry is concerned. We found that it takes a scientific man some time to learn that his interpretations of science may lead him astray where practical application is concerned, and that the empirical and rule-of-thumb way of carrying on processes is to be respected and studied rather than dismissed with contempt. There are many who will agree that in the long chain of functional units which go to make up successful industry the psychological link between the scientific and other staffs still remains to-day one of the weakest.

We started by tackling, amongst other things, the powder metallurgical problems of the metal factory in the making and working of tungsten metal for filament lamps; the making of glass in the glass factory sufficiently uniform that when it goes to the lamp factory it can be manipulated on rapidly operating automatic machines without wastage.

We developed and applied the statistical principles of control of uniformity and quality of the product, which, by the way, was to a large extent the foundation of the quality control technique which was later to spread widely to other industries in this country.

As is usual in all such work, each problem tackled led usually to three or four more. Every solution even partially reached was taken up to be tested out in the practical processes of the factory.

If I may interpose again, just at this time in the early 1920's the radio valve became the adopted child of the lamp industry. The lamp factory and its laboratories were the nursery in which the radio valve was fostered. It was a development which made abnormal demands on the laboratories, and although after a few years radio became a separate branch of industry, with special staffs for giving scientific service, it continued to rely for its successful growth on the scientific staff and resources of the lamp industry. Nevertheless, in our treatment also of the radio valve throughout all its fascinating and brilliant career we have continued to view it firstly as a factory product and secondly as a new scientific device.

Returning to our lamp illustration it was inevitable that there should be passed on to us many questions concerning the utilisation of lamps. Amongst these was that of street lighting. A little scientific thinking and some careful observation showed the need for revolutionary change in the existing practice of street lighting. It led to another of those major developments of which I was speaking.

After the first war you will remember the vogue for what were called Neon signs on the facades of buildings. I am at the moment neither deploring nor welcoming their continued disappearance from our city streets, but it fell to us again to give scientific service to the factory whose staff was struggling with the technical problems of design and manufacture. Whilst the resulting signs were technically excellent, more important consequences followed. The effort to master the scientific essentials of these luminous tubes stimulated our scientists to think and experiment on the possibility of making useful light sources based on the same general principles, that of the electric discharge. So that in the early 1930's, after ten years of immersion in the task of giving scientific service to our factories, the first of the new triple efficiency electric discharge lamps was evolved—that which was applied first to street lighting. It was followed a few years later by the first white fluorescent tubes, evolved, you will note, by the men in our own and other similar industrial laboratories who had qualified in this same school. These new efficient fluorescent tubular lamps are now undoubtedly to be our main electric light sources. They are very good now, but I am sure they will improve further under the stimulation of the same influences as have led to their creation.

Now I feel that the four or five major developments I have just mentioned would hardly have emerged, anyway, in the virile forms they did, apart from the conditions I have been discussing. I should like to think through this example of intimate work with the electric lamp industry (I could have taken other examples from my own or other concerns) that I had made out a case for more emphasis, in our industrial planning, on scientific spade work in, and with, the factory itself and how it can be achieved. I hesitate to suggest that this should be done at the expense of the more detached industrial research for fear of being misunderstood. But, as I said earlier, there are, I find, two ways by which science can try to achieve technical progress in manufacturing industry—both are desirable, but the more effective and the more difficult (by the path of scientific service) needs, in my experience, much more emphasis.

If I had not already spoken too long I would like to have commented upon the national value of these coherent teams of industrial scientists who carry the scientific know-how of manufacturing industry. When such a one, by its technical achievements and its scientific publications, has established its reputation internationally, it finds it has qualified for approaches to or from concerns of comparable standing abroad. The resulting exchanges of visits, of patents, of information and experience are of great individual and national importance. They can bring, as you know, to both sides a valuable increment of new ideas, fresh stimulation and not infrequently unexpected knowledge which saves much time and effort.

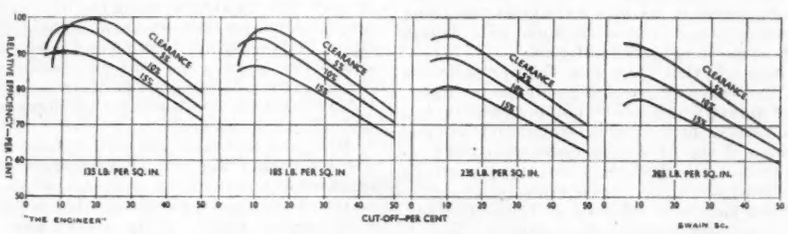
* From a speech by Sir Clifford Paterson at the Annual Luncheon of the Parliamentary and Scientific Committee, January 30th.

The Development of Locomotive Power at Speed*

By E. L. DIAMOND, M.Sc. (Eng.), A.M.I. Mech. E.†

(*Continued from page 203, March 7th*)

Effect of Clearance on Relative Efficiency at Increased Pressure.—Fig. 4 shows the effect of clearance in another way, on a basis of cut-off. It will be seen that owing to the effect of clearance it is theoretically impossible under normal running conditions at speed to realise the higher cylinder thermal efficiencies associated with higher steam pressures as compared with locomotives of lower boiler pressure equipped with modern valve gears permitting early cut-off working. The increase of cylinder thermal efficiency (Rankine cycle) for the same terminal conditions as for the other diagrams and the corresponding decrease in steam consumption are plotted in Fig. 5. It should be said that boiler pressures have been increased primarily in order to increase the power obtainable within the limits of the prescribed loading gauge and axle weight. But, of course, any limitation of efficiency is likewise a limitation of power.



Basis.—Mean effective pressure as for Figs. 1 and 2. Steam temperature at admission, 600 deg. Fah.

The three curves for each steam pressure represent 5 per cent clearance (top curve), 10 per cent clearance (middle curve), and 15 per cent clearance (bottom curve) respectively.

FIG. 4—*Relative Cylinder Efficiencies on a Basis of Cut-off*

Fig. 6 completes the basic data by giving the steam consumption per indicated horsepower-hour over the full range of steam pressures and cut-offs for 5, 10 and 15 per cent clearance respectively. These graphs present the net effect of the changes in opposite directions of the Rankine efficiency and the relative efficiency respectively.

Nordmann's High-Pressure Locomotive Tests.—Professor Nordmann has reported (1938) a systematic series of constant-speed road tests carried out on the German State Railways to ascertain the saving in steam consumption of a number of locomotives built with a boiler pressure of 294 lb per square inch, together with an experimental compound locomotive with a pressure of 368 lb per square inch. Two of the locomotives were also tested at a reduced pressure of 206 lb per square inch to provide a direct comparison. The results are summarised in Fig. 7 and Table I. It will be seen from Fig. 7 that the experimental compound locomotive gave results which stand quite apart, especially in the speed range above 250 r.p.m. For the simple-expansion engines there is no overriding saving in steam consumption.

Table I sets out the comparative results for the two locomotives which ran at two pressures. These locomotives were of similar type, except that one had two cylinders and the other three. The clearance volume in both cases was approximately 10 per cent. At the lower speed at which late cut-offs were used an improvement in relative efficiency was observed, but at the higher speed there was a decrease of relative efficiency despite the earlier cut-offs at the higher pressure. The reduction in steam consumption on an indicated horsepower-hour basis was reported to be insufficient to compensate for the reduction in mechanical efficiency which was found to accompany the higher pressures, so that the net result was actually a higher steam consumption per draw-bar horsepower-hour at the higher speeds. There was considerable variation in the percentage clearance as between the other locomotive types tested, and Nordmann attributed the variable results largely to the effect of clearance.

In comparing these results with the basic data it should be remembered, of course, that this section of the paper deals with theoretical indicator diagrams only. The actual steam consumptions recorded were generally appreciably lower than those given by the basic data (see Fig. 6), due principally to the fact that at the late cut-offs employed throttling at admission is considerable and the effective cut-off was therefore considerably earlier than the nominal. But in their general relationship to each other the results, which constitute the most comprehensive investigation of the effect of increased boiler pressure on the actual performance of locomotives which has yet been published, do demonstrate the value of basic data graphs as a general guide to the locomotive designer.

TABLE I.—*Comparative Steam Consumptions of Two Similar 2–8–2 Tank Locomotives at Two Different Boiler Pressures*
The calculated steam consumptions are those given by Fig. 6 for the same nominal cut-off.

Locomotive.	Speed, r.p.m.	206 lb per square inch. Cut-off, per cent.	I.h.p.	Calcul'd steam consumption, lb per i.h.p.-hr.	Actual steam consumption, lb per i.h.p.-hr.	Relative efficiency (Rankine cycle), per cent.	294 lb per square inch. Cut-off, per cent.	I.h.p.	Calcul'd steam consumption, lb per i.h.p.-hr.	Actual steam consumption, lb per i.h.p.-hr.	Relative efficiency (Rankine cycle), per cent.
Two-cylinder	114	50	1,610	17·1	16·4	71·3	37	1,890	15·2	14·0	75·7
	152	46	1,830	16·3	14·5	81·0	34	2,090	15·0	12·7	83·7
	228	40	1,940	15·6	13·6	86·0	28	2,070	14·3	12·8	83·0
Three-cylinder	114	56	1,529	17·8	17·4	67·4	38	1,741	15·5	15·2	69·7
	152	49	1,768	16·9	15·0	78·3	30	1,970	14·6	13·7	77·5
	228	41	1,811	15·7	14·6	80·4	23	1,895	13·8	14·2	74·5

Advantages of Compound Expansion in Obtaining Increased Cylinder Efficiency with Increased Steam Pressure.—The relative efficiency of the calculated or perfect diagram is greatly affected by the clearance volume, the exhaust pressure and the point of compression, because these determine the additional quantity of live steam required to fill the clearance volume at admission pressure. This quantity expands partly without doing external work, and the earlier the cut-off the greater the resultant percentage loss. There comes a point when the gain due to an increase in the ratio of expansion is exceeded by this relatively increasing clearance loss. This is the reason for the upward trend of the steam consumption curves in Fig. 6 above 250 lb per square inch.

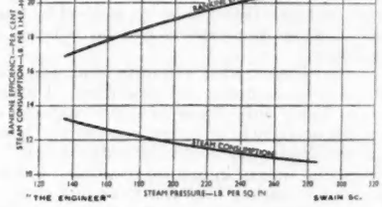
In practice, with imperfect steam circuit and valve gear, the exhaust pressure tends to rise well above the assumed basic pressure at speed, and in consequence a greater weight of steam is trapped and compressed in the clearance space. With imperfect engines it may for this reason be possible to secure a continuous improvement in the relative cylinder efficiency with increase of pressure, even at early cut-offs. The Rankine efficiency, however, decreases at a greater rate with increase of back pressure and the net result is an increase in the specific steam consumption. The effect of back pressure for a typical set of conditions is exhibited in Fig. 8.

Appreciable departures of the relationship between cut-off and compression from that shown in the inset to Fig. 1 will have a greater effect on the efficiency and steam consumption than on the mean effective pressure. A greater percentage of compression is equivalent to a lower percentage clearance, and if it were possible to design the valve gear so as to compress the clearance steam to admission pressure the ideal would be attained and the steam consumption curves would fall continuously with increase of steam pressure.

The difficulty, however, is that locomotives are controlled by throttling when very limited power is required, and under these conditions such a gear would give excessive compression and knocking. As things are, it is a very common practice for drivers to lengthen the cut-off when working with a low steam chest pressure—a practice which is not illogical, as is shown by the curves of relative efficiency.

For the highest efficiency at steam pressures above about 250 lb per square inch, then, compound expansion would appear to be essential. Apart from the fact that it enables the ratio of expansion to be increased in normal running sufficiently to keep pace with the greater working range of pressure, there is the extremely important advantage that only the clearance volume of the high-pressure cylinder affects the basic relative efficiency, provided, as will be explained later, the correct proportions between the cylinders and their clearance volumes are chosen.

There are, of course, many vital practical considerations which may be of more importance to the designer than the attainment of the highest efficiency, which it is beyond the scope of this paper to enter into. It should also be emphasised that high-pressure locomotives run for a large proportion of their time at a reduced steam chest pressure, the full pressure constituting a reserve for maximum efforts. A full appreciation of the conditions governing efficiency will, however, assist in forming a correct assessment of the conflicting factors which the designer has to balance so carefully.



Basis.—Exhaust pressure, 18 lb per square inch abs.; steam temperature at admission, 600 deg. Fah. Available heat reckoned above temperature of exhaust steam.

FIG. 5—*Rankine Efficiency and Corresponding Steam Consumption for Various Steam Pressures*

[The second part of the paper is devoted to an examination of the actual deviation of mean pressure with speed for a wide range of locomotives, including some of the most recent designs, and the reasons for the radical improvement are indicated.]

A Criterion for Calculating Power and Evaluating Performance

It has already been mentioned that Dalby's straight-line law for the deviation of mean

* Institution of Mechanical Engineers, February 21, 1947. Abstracted.

† Mechanical Engineer, Plant Engineering Division, British Iron and Steel Research Association.

effective pressure $p=c-bv$, where c and b are constants for a particular engine and cut-off, implies that the mean effective pressure would steadily fall to zero at a speed of 435 r.p.m. in the case of the locomotive "Schenectady" and as low as 350 r.p.m. in the case of a locomotive of the Chicago and North-Western Railway for which he also plotted curves.

With superheater engines, at any rate, this is contrary to experience. Curves for mean effective pressure have been plotted for a very diverse and representative range of locomotives in this paper, and the plotted points generally show a rapid drop from the calculated mean effective pressure in the initial stages and tend to straighten out later. Such curves correspond to a simple exponential law, the diminution of mean pressure being proportional to some power of the speed of revolution less than unity: $P_N=P_C-kN^{1/x}$, where P_N is the mean effective pressure at N r.p.m., P_C is the calculated basic mean effective pressure read from Figs. 1 or 2, and k is a constant characteristic of the particular locomotive. Trial and error showed that $1/x$ does not vary greatly over the whole range of curves, and that the error involved in taking as a mean the square root of N was generally within the scatter of the points.

It was also found that k is a fairly constant proportion of P_C for any particular engine, so that the equation of the curves reduces to the very convenient form $P_N=P_C(1-1/k\,.\,\sqrt{N})$.

The value of k in this equation is shown for every curve plotted, together with the mean value in the form of a "characteristic power equation" for each locomotive, on the diagrams.

This equation not only gives more accurate results over a wide range of speed for superheater locomotives than Dalby's law, but is a more accurate guide in estimating the power at speed of a projected design than either Cole's constants or the Kiesel formula, with its illogical basis in the boiler, provided appropriate values of the constant k are taken. Each designer can establish such values pretty closely from indicator diagrams from his own previous designs, but for general use the following values are suggested :—

Type of engine.	k.
Simple expansion with short-lap valve gear, piston or slide valves	25
Simple expansion with long-lap valve gear, piston valves	45
Simple expansion with modern design of poppet valves and steam passages of maximum section	75
Compound locomotive with short-lap valve gear, piston or slide valves	30
Compound locomotive with long-lap valve gear, piston valves	50
Compound locomotive with modern design of poppet valves and steam circuit of maximum section	80

The value of P_C may be read directly from the curves in Figs. 1 and 2, but here again the method will give greater accuracy if the value is calculated exactly for the point of compression appropriate to the particular valve gear design adopted. The assumed exhaust pressure must not be modified, however, as this would alter the basis of the constants. The higher the value of k—*i.e.*, the more nearly horizontal the mean pressure curve—and the shorter the cut-off, the more necessary is it that P_C should be accurately determined.

Dalby's law involved two constants, neither of which could be used independently as a criterion of performance. The advantage of a single constant is obvious, but since it has to accommodate two different classes of loss, namely, the pressure drop during steady flow between boiler and valve gear, and the complex cyclic losses between valve gear and atmosphere, any abnormal relationship between the two will be shown up by the fact that no value of k will give a curve conforming with the mean line through the observed values of mean effective pressure. If, on the one hand, the drop of pressure in the steam chest is relatively small but the steam distribution is bad, the slope of the plotted points will be steeper than the exponential curve given by the characteristic power equation, and will in fact conform more nearly to Dalby's straight lines. On the other hand, if the valve gear gives a good steam distribution, but there is an excessive pressure drop through the superheater and main steam pipes, or excessive clearance, then the exponential power curve will be steeper than the mean slope of the observed mean effective pressures. Examples of both kinds of abnormality have already been referred to.

In modern well-designed locomotives such abnormalities generally do not occur, and, as has been seen, the characteristic power equations fit very closely the observed values of mean effective pressure over the normal range of speed. It may therefore be reasonably claimed as an additional advantage of this method of plotting characteristic power curves that it shows up at once such abnormal losses.

To determine the value of k and hence to plot these curves, a value of mean effective pressure P_N at a speed of, say, $N=250$ r.p.m. should be adjudged as falling on the average line through the available data for a particular cut-off. (One observed value only can be taken if no others are available, though the scatter of the points in the diagrams in this paper shows that this may give misleading results.) The value of k is then given by $k=P_C\times\sqrt{N}/P_C-P_N$, P_C being read off from Figs. 1 or 2.

It is sometimes found that the value of k for very short cut-offs differs considerably from the average value for other cut-offs. Such abnormal values should be ignored in determining the characteristic power equation (*a*) because no locomotiveis designed to give maximum power at the shortest cut-offs and (*b*) because the probable error in evaluating P_C increases with short cut-offs, mainly on account of the increase in the proportion of clearance steam.

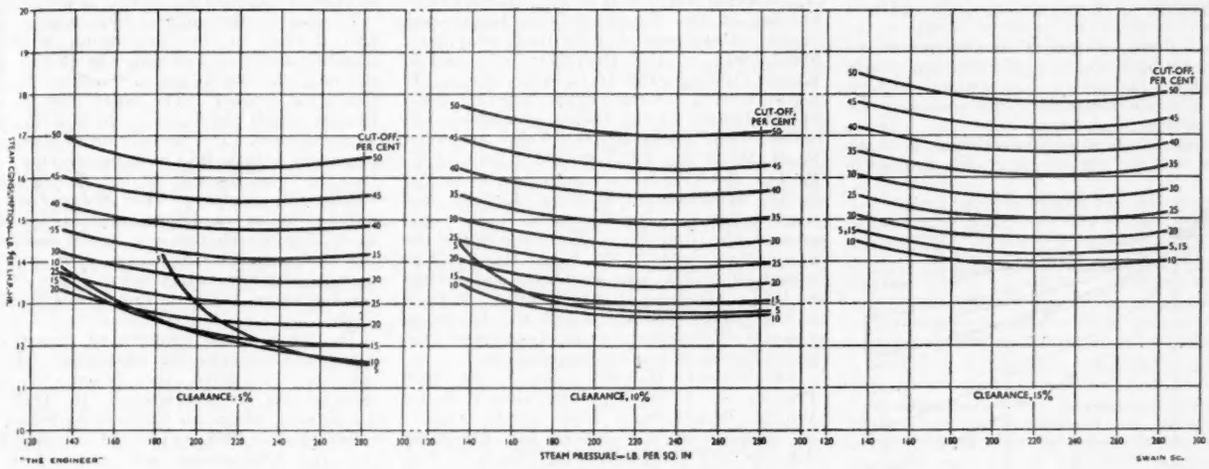
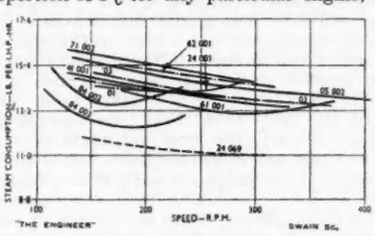


FIG. 6—*Specific Steam Consumptions for Various Steam Pressures and Cut-offs*



——— 294 lb per square inch.
- - - - - - - - Experimental compound locomotive (368 lb per square inch).
— · — · — 235 lb or 206 lb per square inch.

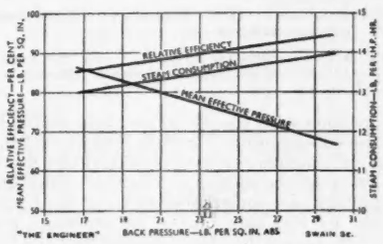
The numbers are those of individual locomotives tested. The two-cylinder and three-cylinder tank locomotives referred to in Table I were numbered (confusingly) 84,003 and 84,002 respectively.

FIG. 7—*Steam Consumption of Various Locomotives with High Boiler Pressures* (*Nordmann*)

The characteristic power equation gives the mean effective pressure, and hence the power at any speed for a particular cut-off. The reason why other proposed power formulæ have been related to the boiler is to eliminate this condition and to give the maximum horsepower of which the locomotive as a whole is capable, or the power at a specified rate of evaporation.

The author contends that this is fundamentally wrong in principle. The first section of this paper shows how greatly the economy of the engine is affected, provided the steam distribution is good, by the relationship of cut-off and clearance to boiler pressure. The good designer will choose the dimensions of his engine so as to enable it to give the maximum continuous power he requires at an economical cut-off for the steam pressure he is using. The data in this paper will facilitate such determination. The logical procedure is therefore to state the power of the locomotive at that specified cut-off and to design the boiler to supply sufficient steam to feed the engine at that cut-off at the highest contemplated speeds, taking a maximum rate of evaporation appropriate to the design of the boiler and not a fixed and universal figure, as was, for instance, the practice of the German State Railways.

The coefficient k also offers a criterion whereby the test results of a completed locomotive may be assessed. Thus Fig. 9 presents the perform-



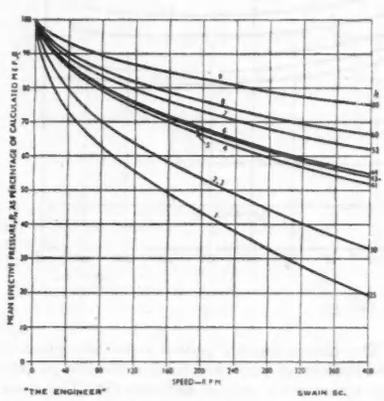
Steam pressure, 235 lb per square inch; cut-off, 15 per cent; clearance, 10 per cent.

FIG. 8—*Effect of Variation of Exhaust Pressure on Relative Efficiency and Specific Steam Consumption*

ances of all the representative locomotives referred to in this paper on an absolutely comparative basis by plotting the mean effective pressures as a percentage of the calculated mean effective pressures as given by Figs. 1 or 2. Comparative curves of mean effective pressure on a speed basis have frequently been published in recent years as a percentage of boiler pressure. Such curves, however, are not comparable, even if they are for the same nominal cut-off, because, as has been shown in the first part of this paper, the percentage of the boiler pressure attainable as mean effective pressure without loss will vary with the boiler pressure and clearance for the same nominal cut-off.

It is important to emphasise, however, that k is not a direct index of thermal efficiency, but rather of the power-weight ratio at high speed, which for railway operation is considerably more important. Such a coefficient derived from test results should also be related always to the designed characteristics of the locomotive, as these are subject to practical limitations which the designer has to take into account. A high value of k, for instance, is not necessary for shunting or banking engines.

The relationship of the coefficient k to the relative cylinder efficiency is of some interest in



The values of k in the characteristic power equation for each locomotive are given alongside the corresponding curve.

1 Midland 4–4–0 superheater locomotive (1917).
2 Original P.O. compound superheater "Pacific" locomotive (1909).
3 Pennsylvania "K4S" locomotive in original form.
4 Pennsylvania "K2S" locomotive.
5 Pennsylvania "E6S" locomotive.
6 L.M.S. rebuilt "Royal Scot" locomotive.
7 Pennsylvania "K4S" locomotive rebuilt with Franklin poppet valve gear.
8 Rebuilt P.O. compound locomotive No. 3705 (Chapelon).
9 Pennsylvania "T1" locomotive with Franklin poppet valve gear.

FIG. 9—*Mean Effective Pressure Curves for Various Locomotives on Truly Comparative Basis*

connection with the use of the data curves for steam consumption (Fig. 6) as a basis for boiler design. Comparison with published test results shows that the minimum recorded steam consumptions are remarkably close to the figures given by the data curves for optimum conditions, except for early locomotives like the Midland engine of 1917, which have a low value of k. Even under conditions of relative inefficiency, as at late cut-offs, agreement is good if allowance is made for the difference between nominal and effective cut-off. Thus, Chapelon has recorded a best steam consumption of 11·7 lb per indicated horsepower-hour, and all the minimum steam consumptions recorded at Altoona are very close to the data figures. It may therefore be said that provided the valve gear is of modern design and does not give rise to excessive back pressure at speed, the steam consumptions given by Fig. 6 are closely attainable in practice at speed. Nor is this surprising, for the losses of mean effective pressure due to attenuation of the indicator diagram are, in the case of superheated steam, largely made up of throttling losses at admission, and back pressure during exhaust. The first only partially represents a loss of efficiency, as the loss of area is partly compensated by the reduction in the quantity of steam admitted as well as the resulting increased superheat, whereas the second represents a dead loss of efficiency.

Test plant data, however, show that at any particular cut-off the steam consumption may vary by over 25 per cent, due to various causes, particularly varying steam temperature and leakage, and that it generally is higher the lower the speed. Moreover, it is well known in practice that the condition of maintenance of a locomotive has an overriding effect on steam consumption, leakage being a principal factor. A margin of at least 30 per cent must therefore be allowed over the minimum consumption given by the data curves.

Centenary Celebrations of King's College Engineering Society

THERE was a large and representative gathering of engineers at the Centenary Celebration of the King's College Engineering Society, which took place on Wednesday, last, March 5th, at the University of London, King's College, Strand, London, W.C.2. It began with a service of Thanksgiving, held in the Chapel of the College, at which the address was given by the Very Reverend W. R. Matthews, K.C.V.O., D.D., Dean of St. Paul's. Afterwards, the guests were received by the Principal, Sir William Halliday, and tea was served. The Centenary Address was given in the Great Hall. The President of the Engineering Society, Mr. R. J. Hartles, welcomed the guests and members, and invited Sir William Halliday to take the chair. Reports of the papers committee and the Industrial Reports Committee having been read, the prizes for the year were then presented.

Sir William Halliday then called upon Professor S. J. Davies, D.Sc. (Eng.), Ph.D., Wh.Ex., M.I.Mech.E., Dean of the Faculty of Engineering, to deliver the Centenary Address on "The Engineering Society." Professor Davies began by reading the Resolution passed on Tuesday, February 2nd, 1847, which brought the Society into being. It reads "That a society be formed under the sanction of the Principal, and with the patronage of the Professors of King's College, London, to be called 'King's College Engineering Society,' and that its object be, to take in the various scientific and engineering periodicals of the day, and that it be hereafter extended to the reading of original papers giving prizes, &c., &c."

Books were taken in for the use of the Society, rules were made, and the organisation drawn up. Papers were read, and a copy of the laws or rules was printed and presented to all members. By the end of 1847 the Society was well launched, and two valuable traditions were established: the reading of papers by the members, and the election of the Committee every term. Both traditions, Dr. Davies said, were still followed, and the reading of papers still formed an important part of the present activities of the Society, while the terminal changes of Committee led to a wide distribution among the members of the responsibility for conducting the Society's affairs. With a view to putting the foundation of the Society at that time into a proper perspective, the earlier development of engineering science at the beginning of the 19th century was surveyed, with the state of engineering practice then attained, while the contemporary engineering societies were reviewed, with the early engineering schools of university rank.

Compared with certain other Continental countries, in particular with France, Great Britain, Dr. Davies went on to say, was in a backward state as regards engineering at the beginning of the 19th century. Outstanding names in that period were those of James Brindley, John Smeaton, John Rennie, James Watt and Thomas Telford.

The state of engineering practice from 1829 to 1847 was then dealt with, London's transport systems, its water and sewerage development, and railway construction and industrial power plant being described. In 1847, the improving status of Naval engineers was recognised by their promotion to commissioned rank. Thus the King's College Engineering Society was formed at a time of rapid expansion in engineering practice generally and in the mechanical engineering branch in particular.

The early years of the 19th century were also marked by the foundation of several scientific societies, including the British Association, the Astronomical Society and the Geological Society. The Institution of Civil Engineers and the Institute of British Architects followed. The Institution of Mechanical Engineers held its first meeting six days earlier than the first meeting of the King's College Engineering Society. That Society was not only, as far as was known, he said, the oldest student engineering society, but it was one of the oldest engineering societies of any kind in this country. Incidentally, the Société des Ingénieurs Civils de France was formed in 1848.

Dr. Davies then went on to review developments in engineering education. The Admiralty established the School of Naval Architecture at Portsmouth, in 1811. At University College an Engineering School was established in 1828, and in 1841 the first Chair of Civil Engineering was established. At King's College, classes for civil engineering and mining were started in 1838, with special lectures in machine drawing, surveying, mineralogy, and manufacturing art and machinery. In 1840 a Professor of Civil Engineering was appointed, and by 1848 there were three other engineering professors. Evidence shows that King's College, in addition to appointing the first engineer as an active professor, also had the first properly constituted engineering school in the United Kingdom. Notable professors were Professor Wheatstone, who held the Chair of Experimental Philosophy, and Professor Daniell, who held the Chair of Chemistry.

The number of full-time students of engineering showed considerable fluctuations; low numbers being associated with the Crimean and Franco-Prussian wars. After the early stages, the numbers never fell below 50 and, until 1880, 75 was a fair average. From 1880 until the first World War, the average approached 100; after that war, there were for three years about 250 students, but a steady average of 120 prevailed until 1935. Evening lectures were initiated in 1860, and continued for half a century. With the growth of technical schools and colleges, however, the need for King's to provide such facilities ceased and, in 1910, evening classes ceased. The college had, however, made a valuable contribution to technical education, by providing such courses when they were necessary.

For a long time King's Engineering School ranked among the largest, but at the beginning of the recent war it was among nine schools of what may be called the second order of magnitude. There were ten other smaller University Schools. The King's Engineering School in its first century, underwent a slow and steady development, and its character as part of a larger college changed but little.

The archives of the Engineering Society were, Dr. Davies went on to say, remarkably complete, and he gave a summary of the papers read. The Society was essentially an organisation of students, conducted entirely by students, and apart from anniversary addresses, given normally by Old King's engineers of distinction, all the papers, with very few exceptions, numbering more than 1100 or a remarkable average of eleven per year, were read by student members. For

many years it was the custom to present bound volumes of THE ENGINEER and *Engineering* as prizes for papers read. Members of the present teaching staff were sometimes asked to preside at meetings when the subjects of papers to be read were known to fall within fields of work in which they were specially interested, but these were the only occasions in which they appeared at the Society's meetings. The experience gained by the members in administering their Society, reading papers, and taking part in discussions, in visits to works, and in taking part in the corporate life of the Society had for some men an educational value of an importance equal to their more formal studies in lectures, laboratories and drawing offices. That side of engineering education had played no small part in achieving the fine professional record of many King's engineers. Some names which might be mentioned were those of Sir W. H. Preece and Sir William Anderson, Sir Douglas Fox, Professor G. F. Armstrong, Sir John Coode and Sir Joseph Bazalgette, Sir Oliver Lodge, Sir John Dewrance and Sir Alexander Siemens. In 1890 Professor John Hopkinson came to the college as the first holder of the Siemens Chair of Electrical Engineering, and among his pupils were four outstanding men, Sir John Snell, Mr. C. H. Wordingham, Mr. Llewellyn Atkinson, and Mr. J. S. Highfield, all of whom were later Presidents of the Institution of Electrical Engineers. Other King's engineers who became Presidents of the Institution of Civil Engineers were Mr. Harrison Hayter, Sir Brodie Henderson, Sir George Humphreys, Sir Leopold Savile, and Sir Alexander Siemens. Among other outstanding students were Sir Gerald Muntz, Sir Noel Ashbridge, Professor R. C. C. Batson, and Dr. D. M. Robinson, now Professor of Electrical Engineering in Birmingham University.

The paper, the *King's Engineer*, had been published annually since 1922, under the joint auspices of the Society and the Old Students' Association.

The continuity of the Society, Dr. Davies went on to say, was no matter of chance, and was based on the conditions under which educational work was carried on in the College. It was a normal unit of less than 2000 students and teachers, which was divided among six faculties, which ranged from Theology, Letters and Law to Pure Science, Medicine and Engineering. From 1935 until the outbreak of war all places had been filled. There was at present a wave of ex-Service students, which was possibly a third of its way through its length.

The annual output of students from the twenty-two University Engineering Schools in this country was before the war well under one thousand. The present output in Switzerland, with one-tenth of our population, was probably not far short of that figure, while the equivalent output from the German Technical High Schools was at least four times that number. The view was now common that we must double our output of students, and the question arose as to whether schools should become larger or whether there should be more schools. Contrasting our schools with those abroad, Dr. Davies said that buildings abroad were usually larger and architecturally more attractive. Instructional equipment was generally more lavish, and was well installed. But in general, the schools were less suited to practical purposes than were our own. Their units were usually larger, but the average number of students per teacher was not probably much greater than ours. The distribution as regards senior and junior teachers was different, the proportion of juniors here being less than abroad. Our practice was generally to have small groups guided in their studies by senior teachers, while their practice was large groups, who attended lectures by the Professors, with instruction by junior men in laboratories and drawing offices. The relation between senior teachers and individual students abroad, therefore, was, and must be, less close than here. In this we stood at a considerable advantage. He believed also that the relationship between the students themselves was much less close than here, with a consequent reduction of the educational value of student friendship and association. The question of the size of school was thus fundamental, and he, Dr. Davies, believed that for the non-residential conditions which were found in most of our Universities, a medium size of engineering school offered the best solution. When we had brought our smaller schools up to that level of size, we should not go beyond it, but should add to the number of our University Engineering Schools.

In general the largest schools abroad were independent of the Universities, the smaller being as in this country, faculties of Universities. One organisation, such as the Massachusetts Institute of Technology, might be of great value to us, but for the broader culture of the engineer Dr. Davies preferred him to be trained in a faculty or school which formed part of a larger college or University. At King's College, he had watched succeeding generations of engineering students benefiting from association, one with another, and stimulated by the opportunities provided by the Engineering Society; he had watched young men broaden their outlook by virtue of the college background, and the contact with students from other faculties; he had sat at examiners' meetings in which every member had known something from personal experience of practically every student whose results were under consideration. His earnest hope, Dr. Davies concluded, was, therefore, in whatever direction the College might develop in the future, it might never depart from the conditions of size and constitution which had made possible the historic event which all had met to celebrate that day.

Arrangements are being made to publish a Centenary History of King's College Engineering Society, and those who desire a copy of this volume to be reserved for them are invited to communicate with the College, addressing their letter to Engineering Society Centenary History, King's College, Strand, London, W.C.2.

Alexander Graham Bell Centenary

A LARGE and appreciative audience assembled in the Central Hall, Westminster, on Monday, March 3rd, to hear Colonel A. Stanley Angwin deliver his I.E.E. lecture commemorating the centenary of Alexander Graham Bell. The President of the Institution of Electrical Engineers, Mr. V. Z. de Ferranti, was in the chair and the lecturer was introduced by the Postmaster-General, the Right Hon. the Earl of Listowel. In his lecture, Colonel Angwin showed, with the help of a series of striking demonstrations, how much the modern science of telephony owed to the pioneer work of Bell. Born in Edinburgh on March 3, 1847, Bell studied at University College, London, where his interests included physiology, music and elocution. When Bell, still a young man, emigrated to America these interests combined to focus his attention on the problem of making sounds intelligible to the deaf. While Bell was experimenting with the "harmonic telegraph" he realised the immense significance of the discovery that a movable iron diaphragm in association with an electromagnet formed a reversible device whereby sound waves could be translated into corresponding variations of electric current, which could be transmitted along wires to a distant point and could there be reconverted into a faithful reproduction of the original sound pattern. Without any loss of time Bell proceeded to turn this discovery to practical advantage. He demonstrated his first telephone in America in 1876, and a year later he crossed the Atlantic to describe his researches in an address before what was then known as the Society of Telegraph Engineers in London. One of the earliest installations of the Bell telephone was carried out at Marlborough House in 1878. From such early beginnings there grew the complex and extensive internationally linked telephone systems of to-day. To link past and present, Colonel Angwin showed how the growth of modern telephony was helped by developments such as the loading of telephone cables, the introduction of thermionic valves which made radio telephony possible, the use of repeaters and the coaxial cable. Fundamentally, however, all this progress rested upon the efforts of the early pioneers and, to do justice to Graham Bell's individual contribution, tribute must be paid to the practical acumen which expressed his confidence in the future of the telephone.

Annual Report of the Safety in Mines Research Board

THE twenty-fourth annual report of the Safety in Mines Research Board, which has now been published, gives a brief account of the Board's investigations during 1945. It is divided into the following sections: coal dust explosions, electrical researches, mining explosives and shot firing, falls of ground, haulage and wire ropes.

In the section on coal dust explosions the outstanding feature of the work carried out confirms and emphasises the danger of exposed layers of coal dust, to which attention was drawn in the previous report. Experiments have established that a mild explosion, initiated by an igniting source of low violence, may be propagated by the coal dust which it raises from a surface layer only four hundredths of an inch thick, even when the coal dust rests on a stone dust deposit nine times its own weight. It is pointed out that the danger of a surface layer of coal dust may be overlooked if safety measures are based solely on analysis of samples taken from the top ½in or so of dust. The danger can only be countered by the frequent application of stone dust in small amounts.

Electrical researches have shown that the determination of the "safe gap" for enclosures for flameproof apparatus, which governs the tolerances permitted between flanges, gives figures which vary considerably with the point at which ignition may occur within the enclosure. It would seem necessary now to abandon the idea that flange protection depends on the cooling of the flame gases by adiabatic expansion at the moment when they escape from the enclosure, or on cooling by loss of heat by conduction whilst they are in contact with the flanges. The most acceptable hypothesis, based upon experiments, is that the major factor is the turbulence of the flame gases and that this "drowns" the flame by preventing sufficiently long contact between any part of it and the inflammable mixture into which it is projected.

In connection with the possible application in this country of the "Coal Plough," a device developed in Germany whereby coal is sheared off the coal face, an apparatus has been designed to determine the resistance to cleavage of coal *in situ*.

I.E.E. RADIOCOMMUNICATION CONVENTION.—The Institution of Electrical Engineers is holding a Radiocommunication Convention at Savoy Place, Victoria Embankment, W.C.2, from March 25th to 28th. The President of the Board of Trade, Sir Stafford Cripps, will open the Convention on March 25th at 5.30 p.m., when an address on "Telecommunications in War" will be given by Sir Stanley Angwin. The morning session at 9.45 on March 26th will be devoted to "Long Distance Point-to-Point Communication" and "Naval Communication," and in the afternoon at 2.30 "Military and Aeronautical Communication" will be discussed. An evening session at 6 o'clock will consider "Pulse Communication." The sessions on March 27th and 28th will begin at the same times and discussions will take place on "Short-Distance Communication," "Direction-Finding," "Wartime Broadcasting," "Propagation," and "Radio Components." At the evening session on March 28th, Sir Clifford Paterson will review the Convention and deal with future trends of radiocommunication.

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THE DEBATE ON THE ECONOMIC SITUATION

THE debate in the House of Commons on the nation's economic situation, a debate which, as we go to press is still in progress, had as its subject problems that affect every individual and every business in the country. It ranged over a very wide field, from broad questions of international economics to the recruitment of workers from displaced persons' camps and from wide national financial discussion of inflation and deflation to the transfer of labour from football pools organisations into industry. Unfortunately, paper supplies being even more limited now than they were before the fuel crisis, we cannot spare the space even for a summary of that debate. We can do no more than refer to certain matters raised in it that seem to us of particular interest to engineers.

The basic shortages from which the country is suffering in its attempt to raise production generally well above pre-war levels, both for export and for home consumption, are those of electric power, coal and labour. But like Mr. Lyttelton, we confess to being more "haunted by the fear of our production being held up by shortages of raw materials, or a few of them than . . . by actual shortage of labour." For, given fuel and power, much can be done to overcome labour shortages. But without ample supplies of those commodities, the effects of shortage of labour must be magnified. The more important raw material shortage is unquestionably that of coal. Last week, on this page, we ventured to criticise the Government for setting, in the White Paper, so low a target for the 1947 production of coal as 200 million tons, since we regarded that quantity as inadequate to support the planned expansion of industry this year. We also criticised the Government's intention, expressed in the White Paper, of not making use of the whole capacity of the steel industry. Both points received, in the debate, the weighty support of Sir Andrew Duncan, who said that the restraint on steel would follow through into the engineering and metal-using trades and that to encourage less production in those trades in 1947 than in 1946 was to check back to a lower rate than had already been reached in 1946. Yet those industries were the basis on which we hoped to have a rapid re-equipment of British industry. Further, as Mr. Lyttelton pointed out, since there can be no increase in the exports of steel and textiles in 1947, special reliance will have to be placed on, amongst others, the engineering and vehicle groups to raise their exports to new high levels. These happen to be great steel-using trades. The rate of exports of machinery, declared Mr. Lyttelton, would have to rise from a level of 47 per cent above that of 1938 in the second quarter of 1946 to 119 per cent in the second half of 1947, and of vehicles similarly from 77 per cent above the level of 1938 to 151 per cent above that level. He did not regard those figures as practicable, and it is certainly pertinent to ask how such an expansion is to be brought about if steel supplies are permitted to be limited by shortages of coal. On the subject of coal, Sir Stafford Cripps did provide an estimated coal account in the debate. But, unfortunately, it related only to those six summer months during which stocks are normally collected against higher winter demands. He showed that after allowing for the needs of other users, including electric power stations, gas works, railways and domestic fires, &c., the remainder amounts to "exactly two-thirds of the total estimated requirements if industry was running full out." Only if an average increase of coal production of about 10 per cent above the present estimate is obtained in the next six months will there be enough to maintain full industrial production. The power supply position is not quite so depressing. The Government hopes to avoid "large-scale" load-shedding by "a wholesale staggering of working hours." But it may be worth while to point out — for in reference to staggering Sir Stafford mentioned "steps which are not merely coal saving"—that since the object of staggering is to permit more units to be generated without exceeding peak capacity, more coal, not less, must be burnt. To meet the country's economic problems, the Government has devised the plan set out in the final section of the White Paper. But it is difficult to see either from the Paper or the debate by what means that plan is to be carried out, and how planned changes in the relative strengths of the labour forces in the various industries are to be effected. In the debate only one further major proposal emerged. Sir Stafford stated that the Government proposes to set up yet another body concerned with industrial planning. It is to be a joint planning staff, composed mainly of departmental planning officers, under a full-time executive head and its functions "will cover the whole field of general planning." It will also be "specially concerned with the more immediate task of reviewing the programme for the rest of 1947 in the light of developing conditions." Further, for Government consultation with industry, Sir Stafford said, "there would be a small board representative of the Government's planning staff and of both sides of industry, which would meet from time to time throughout the year to follow developments of the plan." It seems that the Government hopes to make a reality of its plans by asking industry, through the new board, its own organisations, and that confusing array of other boards, and consultative councils and committees already set up to do much of the work of control voluntarily itself, whilst, to judge from Mr. Isaacs' speech, labour is to be exhorted and persuaded, voluntarily, to enter or to transfer to those industries that are particularly short of manpower. Both sides of the House were in agreement that there should be no direction of labour.

Certain of Sir Stafford's remarks were undoubtedly directed to members of trades unions. "In the long run we should look to the raising of our standard of living along the line of reduced prices and stable wages rather than on the basis of ever increasing wages and prices chasing one another and, so far as past experience goes, prices always winning"; and, again, "The nation cannot afford shorter hours of work unless the change can be shown to increase output," a remark which brought from Mr. Lyttelton a request for a statement as to the probable effect upon output of the five-day week in the coal mines, shortly to come into operation. Mr. Isaacs further emphasised this point when speaking of the many problems inherent in the staggering of hours of work. He said that any reduction of working hours involved would seriously weaken our economic position unless output per man-hour could be increased. It will be interesting to see, in the coming weeks and months, how far such remarks will go in convincing workers that the present is not the time to press for higher wages and the 40-hour week, projects worthy in themselves but wholly out of tune with the nation's economic circumstances. It is to be feared, however, that, though union leaders can hardly fail to be influenced, it will be long before the views of the rank and file can be altered. "Too often," said Mr. Lyttelton, "the man in the street thinks about international balances of payments and standards of life as if they were abstractions existing only in the minds of the banker and the economist. Too seldom does he understand that the standard of life means what we eat, what fuel we have to warm ourselves and to cook our food, what clothes we wear and what shelter we have over our heads." The fuel crisis should never have been allowed to occur. But some good may accompany its many evil results if the resulting stoppage of industry and consequent unemployment brings home to

everyone the close connection between the economic condition of the country and the livelihood and home comforts of the people.

LOCOMOTIVE POWER AT SPEED

THE incessant demand for higher rates of travel with heavy trains, which has been more especially manifest in passenger services, has naturally called for greater power output on the part of locomotives. Further, as, of course, any increase in power can only be obtained by a corresponding increase in the mean steam pressure acting in the cylinders, it follows that the design and proportioning of cylinder steam ports, together with adequate valve action to give a proper steam distribution, must both separately and collectively be given close attention. Stated quite shortly the aim must be to pass the greatest possible weight of steam through the cylinders per unit of time, and it is this latter consideration of the time interval progressively shortened at high speeds that presents the crux of the problem. The ideal would, of course, be the maintenance of a definite mean pressure throughout the entire speed range. For then, power would increase directly with speed. That ideal, however, is far from being reached, though improvements made in cylinder design and in the steam distribution have greatly increased mean pressures at given rates of cut-off through the higher speed range—a fact brought out in an interesting manner by the paper presented for discussion by E. L. Diamond at a meeting of the Institution of Mechanical Engineers, London, on February 21st, of which we include an abstract in the present issue.

The author divided his paper, entitled "The Development of Locomotive Power at Speed," into two parts. In the first, the efficiencies of the steam action in the cylinders at different steam pressures and specific steam consumptions per indicated horsepower, corresponding to various rates of admission and for different boiler steam pressures, were estimated. In making these computations, assumed clearance volumes of 5, 10 and 15 per cent were taken into consideration. As a basis for these computations, the author used ideal indicator diagrams, constructed for each different steam pressure, and a constant steam temperature of 600 deg. Fah., while the exhaust pressure was taken as being in all cases 18 lb per square inch absolute. The second part of the paper was devoted to what is really its main purpose, namely, the determination of the mean effective pressure in cylinders having a definite clearance volume expressed as a percentage of the swept volume at any speed and rate of cut-off. The formula proposed for determining the mean pressure is based on the mean effective pressures shown by the ideal diagrams, corrected by a factor, while the fall in pressure with increasing speeds in revolutions per minute is taken as being proportioned to the square root of the assumed speed. Characteristic curves of mean pressure, estimated according to the author's method, drawn through plotted points from various tests, show fair agreement, from which it is concluded that the formula "is a more accurate guide in estimating power at speed of a projected design than either Cole's constants or the Kiesel formula, with its illogical basis in the boiler, provided appropriate values for the constant are taken."

Whether or not agreement will be found with that statement seems very problematical. For, if it is conceded that the proposed method for computing mean pressures is valid, the actual cylinder power available will always be determined by the steaming capacity of the boiler, as, until that capacity is established, it is impossible to know at what speed a given cut-off can be maintained. The estimation of the mean effective pressure in locomotive cylinders under various conditions of speed and rates of expansion is a complex problem, due to variations in both the pressure and temperature of the steam at admission and exhaust, varying as they do at different rates of flow and hence with different speeds and cut-offs. It is, therefore, natural that in the discussion doubt was expressed whether Mr. Diamond's estimates are well founded. That locomotive performance at high speeds has been greatly improved of late can be conceded, and in this connection the author's reference to the pioneer work by G. J. Churchward at Swindon in years long passed is timely. Recent improvements in cylinder design are entirely in accord with Churchward's principles, instigated about 1902. Modern designers may, therefore, take credit for following a path clearly marked out many years ago.

The Institute of Metals

No. I

THE annual general meeting of the Institute of Metals was held in London on March 5th, 6th and 7th. The President (Col. P. G. J. Gueterbock) was in the Chair.

The Report of the Council and the Statement of Accounts were then presented and adopted.

The President, commenting on the Report, referred to the Mond Nickel Fellowship. He recalled that their foundation was announced a year ago and said that the necessary legal documents had been approved by the five operating Institutes and the Mond Nickel Company, and the signatures would be attached in the near future. It was hoped in a few weeks to be able to invite applications for the Fellowships, with a view to awarding at least one or two during the current year.

No other nominations having been received, those nominated at the autumn general meeting to fill vacancies among the honorary officers and on the Council were declared elected, as follows: President, Col. P. G. J. Gueterbock; Vice-President, Mr. John Cartland; Members of Council Prof. Leslie Aitchison, John Arnott, Dr. Maurice Cook, and Mr. A. J. Murphy.

The President expressed his appreciation of his election as President for a second year, and added thanks on behalf of the new Vice-President and new Members of Council. Under the rules, a certain number of Members of Council retired by rotation. These were Mr. G. L. Bailey (Vice-President) and Sir Clive Baillieu, Dr. A. Gwyer and Dr. Sykes (Members of Council). He added that Mr. Bailey had been appointed to the Council to represent the Institution of Metallurgists, but to him and to the retiring Members of Council he proposed a vote of thanks for their past services.

This vote of thanks was cordially given.

The President announced that the Council had decided this year to award the Institute's Platinum Medal jointly to Dr. J. L. Haughton and Dr. Marie L. V. Gayler (Mrs. Haughton). The scientific achievements of this lady and gentleman were so well known that he need not go into any detailed account of their brilliant scientific work, which chiefly had been concerned with the structure of light metal alloys. But he felt that the Institute in honouring Dr. and Mrs. Haughton was honouring itself. It was a unique occasion in that husband and wife were both fully qualified to deserve the highest honour the Institute could bestow. Seldom, if ever, could such intellectual accord have existed between husband and wife and have led to such important scientific results.

Dr. Haughton expressed the great appreciation of his wife and himself of the very great honour that had been done them, an honour which they would feel unworthy of if it were not for the fact that in making these awards they felt the Institute had also made them to the Metallurgical Department of the N.P.L., for if it had not been for the great facilities, enthusiasm and help given in that establishment they would never have been standing in this somewhat embarrassing position.

In the afternoon the following three papers were presented and discussed together :—

HOT-SHORTNESS OF SOME ALUMINIUM-IRON-SILICON ALLOYS OF HIGH PURITY
By A. R. E. SINGER AND P. H. JENNINGS

HOT-SHORTNESS OF THE ALUMINIUM-SILICON ALLOYS OF COMMERCIAL PURITY
By A. R. E. SINGER AND P. H. JENNINGS

PROPERTIES OF THE ALUMINIUM-SILICON ALLOYS AT TEMPERATURES IN THE REGION OF THE SOLIDUS
By A. R. E. SINGER AND S. A. COTTRELL

Mr. Singer, presenting these papers, spoke of the background of the research involved in these three papers and said the field originally allotted to the research team some two-and-a-half years ago was the welding of aluminium alloys, but this was found to be too large. Therefore, it was felt that a small part should be chosen, and that chosen was the cracking of aluminium alloy welds. It was felt by the team that the cracking of such welds would probably be found to be connected with the hot shortness properties of the alloys themselves and that an investigation into this would provide a good start. In addition, owing to limited resources and also time limitation, it was found necessary to concentrate on one or two alloys only, and they chose the aluminium-silicon system for two reasons. First, because it was a simple eutectiferous system and, secondly, because a certain amount of work had already been done upon it. Later, they considered the aluminium-iron-silicon alloys. There was both the practical and the theoretical approach. On the practical side they carried out ring casting experiments and welding experiments, and tried to find out

what was happening to these alloys. On the theoretical side, they carried out a number of tensile tests at high temperatures to try and explain the hot shortness phenomena. Finally, an attempt was made to correlate these two lines of approach. Although they felt they had had a certain amount of success in explaining the phenomena and how it varied in the aluminium-silicon series, it was important not to suppose that all cracking in aluminium alloys was due to hot shortness. In fact, it was known that in certain cases, with certain alloys, cracking that was not due to hot shortness took place at high temperatures. Nevertheless, the authors felt there was a tremendous field in this connection which had been neglected very much in the past, and it would be an advantage if further work was carried out. During the course of this work, a tremendous number of interesting problems were brought to light and many seemed to be of considerable importance, from both the practical and the theoretical angle. At the same time, they had had to leave many of these problems unsolved.

Discussion

Dr. C. J. Smithells (British Aluminium Research Laboratories) said he had no fault to find with the authors' conclusions, but felt that, as summarised at the end of each paper, they might easily give a wrong impression of the composition and properties of commercial aluminium and its alloys as manufactured to-day. In the first paper it was stated that the hot-short temperature range in the aluminium-silicon alloys increased with increasing silicon to a maximum at approximately 1·8 per cent silicon, and then decreased to a low value. In the second paper it was stated that there was a hot-short range in the commercially pure aluminium-silicon alloys containing approximately 0·2 per cent of iron and between 0·25 and 3 per cent silicon. So far as he was aware, however, there were no commercial aluminium-silicon alloys containing the amounts of silicon indicated. The lowest silicon content permitted by any specification for ingot or castings was over 5 per cent, which was well outside the hot-short range indicated. This was admitted by the authors and therefore it was misleading to refer to these materials as commercially pure aluminium-silicon alloys. The authors also referred to the danger of an undue amount of silicon being present in commercial aluminium, but the silicon in commercially pure aluminium would never be allowed to rise to 0·7 per cent, much less to 1·8 per cent with iron at 0·2 per cent. In the third paper, it was recommended that the silicon content should not exceed the iron content in commercially pure aluminium. This was a sound conclusion, but it was not new. It was already the general practice to control the iron-silicon ratio in this way, since other properties might be adversely affected if the silicon content exceeded the iron content.

Mr. R. W. Ruddle (Research Investigator, British Non-Ferrous Metals Research Association) confined his remarks to the first two papers and said it was interesting that the theory advanced in them to explain the occurrence of hot-shortness in aluminium-silicon alloys was in substantial agreement with that proposed by Lees of the B.N.F.M.R.A., in 1946, *viz.*, that the susceptibility to hot-shortness of an alloy depended largely on the magnitude of the temperature range between the liquidus and solidus in which the alloy was coherent, this dangerous temperature range being determined by the freezing range and eutectic content of the alloy. Like Dr. Smithells, however, he felt rather doubtful about the method of assessing the relative susceptibilities of the various alloys. In this, he referred to the ring castings in particular. There was no apparent reason why a large number of small cracks should be more significant than one large one encompassing and extending through the whole section, yet, using the method of assessment employed by the authors, this was the case. In considering this point, the effect of the grain size of the material on the mode of occurrence of the cracking was perhaps important. It might be expected that a large grain would lead to the formation of a few big cracks, whereas a fine-grained material would tend to exhibit a larger number of small cracks. There was some indication in the papers that this was, in fact, the case, and it would be interesting to have confirmation from the authors. Surely the only really satisfactory criterion of the susceptibility to hot tearing of an alloy was whether the alloy cracked at all under given casting conditions. For this reason it seemed to him that a series of moulds graded according to the restraint imposed on the casting, similar to those employed by Lees, offered a much better test. Possibly the best test of all was afforded by a single mould, the restraint imposed by which was adjustable. He also felt that a test sample for hot tearing should have a more uniform rate of cooling over its cross-section than was provided by the authors' test.

He was glad the authors pointed out that their experimental results were not necessarily directly applicable in practice. The results given in the papers seemed to imply that alloys containing more than about 3 per cent silicon were virtually free from danger to hot tearing, but this was not necessarily true of a production casting in such alloys. Cracks might be expected to occur under some circumstances in castings made of materials of very low susceptibility-rating, such as high eutectic alloys. He asked for the authors' views on the nature of the forces causing cohesion between the dendrites in the solidifying alloy.

Mr. D. C. G. Lees said there was one point to which he would like to call special attention, and that was the effect of non-constitutional changes on resistance tearing. It was well known in the aluminium casting industry that hot tearing could be eliminated, or much reduced, by dissolving gases in the molten alloy. It was also well known that fine-grain alloys had much greater resistance to tearing than coarse grain, and he would like to know how these two factors affected the critical temperature range which had been so much used by Mr. Singer. It seemed to him that possibly a combination of the two was seen at its weakest in that connection. Mr. Singer, in his casting experiments, had used an open-top mould but that led to a chilling effect which might change the rate of solidification, so that the grain size was altered, which was of considerable importance. Therefore, he would have preferred the use of a mould which had not this open top. He was also surprised that Mr. Singer had used the mould without dressing, which seemed to him likely to introduce certain dangers which were likely to be serious.

Mr. W. K. B. Marshall (Aluminium Plant and Vessels Company, Ltd.) said the authors had asked for information as to the relationship between their work and practical experience in welding. There was no serious problem in the welding of pure aluminium. The producers of aluminium, for other reasons, maintained an iron content greater than the silicon content. It had been of the order of one-and-a-half times and sometimes twice the silicon content. His first impression on reading these papers was that an increase in the purity of aluminium tended to reduce its hot cracking propensity, but he had looked at the matter rather more closely and had found there was very little difference as between 99 per cent aluminium and 99·9 per cent in the tendency to hot cracking or, at least, to cracking in the weld. Indeed, there was a general impression among welders that there was an increase in the tendency to hot cracking in the case of the higher purity metals, and, indeed, in cases he had examined that had also been his impression. He thought this was due to the fact that high purity metals were usually welded in much thicker gauges, and were used primarily for their corrosion resistance, for use in nitric acid plants and the like, and because of the heavier gauge the tendency to cracking would in any case be greater. He mentioned this because it pointed out the danger of drawing conclusions from general impressions and, personally, he felt convinced that the authors were not correct in the view put forward in the paper.

Mr. Singer replied shortly.

(To be continued)

Obituary

COMMANDER KENNETH EDWARDS, R.N.

It is with deepest regret that we have to record the death on Friday, last week, March 7th, in London, at the early age of 44, of Commander Kenneth P. M. Edwards, R.N. (Retd.), who was the Naval Correspondent of the *Daily Telegraph*, and, by a happy arrangement, acted in a similar capacity for The Engineer.

He was the eldest son of the late Brigadier-General J. B. Edwards, and was born in India, at Naini Tal, in the United Provinces. He received his education at Haileybury College, and entered the Royal Navy in 1920, specialising in submarine service. He served in H.M.S. "Queen Elizabeth" and "Iron Duke" during his midshipman days, and on becoming Lieutenant he served in submarines till 1928. Following a short period in the destroyer H.M.S. "Vidette" and the cruiser H.M.S. "Cleopatra," he returned to submarines, and was in command of "H. 48" at Portsmouth when he retired in 1932.

On retirement he devoted himself to journalistic work, which he had already begun in 1930. In 1932 he was appointed the Naval Correspondent of the *Morning Post* and, later, of the *Sunday Times*. On the outbreak of war in September, 1939, he was recalled to the Royal Navy and served in the Press Division at the Admiralty until 1942, when he joined the *Daily Telegraph*. In addition to his press work, he found time to write no less than six full-length books in eight years. He became a recognised authority on naval matters, more particularly on subjects dealing with strategy and the border line between naval operations and high politics. His first book, which was published about ten years ago, told the story of "Mutiny at Invergordon" and other well-known books were "We Dive at Dawn" and "The Grey Diplomatists." His last book, which bore the title "Operation Neptune," and tells of the part played by the Royal Navy in the D-day operations, appeared only a short time ago.

His work for The Engineer always bore

the mark of his love of the Navy and its work. His annual reviews in the difficult war period were of especial interest, and in two articles he dealt with such subjects as "1943, The Decisive Year at Sea," and "1944, The Year of Attainment." This year he took as his subject "Naval Replacement," and his last contribution to our pages appeared on February 14th, describing the laying-up of the American Navy. He was well known in this country and America in naval and journalistic circles, and his unexpected death at such an early age is widely regretted.

WILLIAM A. MACFARLANE

ELECTRICAL engineers will regret to learn of the death, at his home in Cathcart, Glasgow, on February 22nd, of Mr. William A. Macfarlane, one of the original directors of the Macfarlane Engineering Co., Ltd., of Cathcart. Mr. Macfarlane, who was born in Glasgow, was 74 years of age. He received his early education at Allan Glen's School, Glasgow, and continued his technical training at the Old Glasgow Technical College. He served his apprenticeship with the firm of G. and J. Weir, Ltd., of Cathcart, and on completing his training was for some time employed in the drawing-office of the Mirrlees Watson Company, Ltd., Scotland Street, Glasgow. In 1895 he joined the nearby firm of Watson, Laidlaw and Co., Ltd., as assistant to his father, the late Mr. J. W. Macfarlane, who was then the general manager of the company. After twelve years with the Watson, Laidlaw Company, he went to Alloa and joined the British Electric Plant Company, Ltd., as its works manager. That position he continued to occupy until, in 1911, he joined his family in forming the Macfarlane Engineering Company, Ltd., at Cathcart. During his thirty-six years as director of the firm, he performed many functions during the formative years of the firm, and its growth. He was the joint inventor of numerous electrical developments connected with the name of Macfarlane.

ALFRED HARTLEY JAY

WE regret to have to record the death, as a result of injuries received in a car accident on February 22nd, of Dr. A. H. Jay, of the central research department of the United Steel Companies, Ltd., Sheffield. Dr. Jay, whose brilliant career was thus cut short at the early age of forty, graduated with honours in physics at Manchester University in 1928. He remained at Manchester until 1933, carrying out, in association with Dr. A. J. Bradley, important researches on the X-ray analysis of alloys and incidentally effecting major improvements in the technique and accuracy of X-ray measurements. He designed a high-temperature X-ray camera for precision measurements, and with its aid investigated the thermal expansion of quartz and other substances. It was during this period that he held the Priestley Scholarship and the Beyer Fellowship of Manchester University, as well as a research grant from the Metropolitan-Vickers Electrical Company, Ltd., Manchester. He was awarded the degree of M.Sc. in 1931 and Ph.D. in 1933, and was a Fellow of the Institute of Physics.

In 1933 he joined the United Steel Companies, Ltd., and under the guidance of the late Dr. Swinden turned his attention to numerous steelworks' problems, the most fruitful of which proved to be those relating to refractories and slags. In this work his success was outstanding. His X-ray analysis of a number of perished dolomite bricks gave the clue to the real cause of failure and pointed the way to the production of the present-day stabilised dolomite brick. He made a thorough study of fireclay refractories and of the mineralogical constitution and properties of fireclay bricks in relation to the firing treatment they had received.

During recent years he devoted much attention to the study of steel-making slags, often arriving at novel conclusions, the implications of which have not yet been fully explored. His investigation of the constitution of basic open-hearth slags, published by the Iron and Steel Institute in 1945, introduced a new conception of molten basic slag as a suspension of two solid phases in a liquid phase, and has been followed by another paper, not yet published, on the mechanism of carbon removal by oxidation from the bath in the open-hearth furnace.

Dr. Jay was the author of many scientific and technical papers, and his early death will be felt as a severe loss by all concerned with the application of science to industry.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FUEL AND THE FUTURE

SIR,—It is evident from Mr. Dimbleby's further letter in your issue of February 7th that he does not appreciate the consequences of arriving at a cycle efficiency greater than Carnot's limit for the temperature range concerned. The possibility of doing this would imply defeat of the second law of thermodynamics, and would open up the prospect of an inexhaustible source of heat available for conversion into mechanical work. Grade of heat would then be immaterial since any grade of heat could be converted into a higher grade by a self-acting mechanism.

Faced with this conclusion most engineers would look for the fallacy in their argument. The fallacy in Mr. Dimbleby's argument is not difficult to find. It consists in the use of a formula for efficiency calculated for a gas satisfying the law of constant PV/T and then substituting in the formula obtained values of PV and T which deviate from this law. If the efficiency were determined by measurement from a diagram drawn to scale representing a cycle consistent with physical characteristics of CO_2, it would be found that the efficiency would be less than the Carnot efficiency. Its margin of approach to the Carnot efficiency would depend upon the extent to which the cycle approached the condition of reversibility.

All this is fundamental theory, which is not upset by using a cycle with a working fluid, which closely approaches its critical temperature during its course of action.

G. F. LAKE.

Stockton-on-Tees, February 12th.

SIR,—In Mr. Dimbleby's two letters in your issues of December 13th and February 7th, the suggestions and optimism are based on a number of mistakes in the reasoning and calculations which I will point out below, but I should first like to say a word about the "Carnot efficiency."

The efficiency of any heat engine is defined as (work produced) ÷ (heat taken in by engine). In text books on thermodynamics the following three main points are proved: (1) All "reversible or ideal heat engines, that is engines in which there is no friction, have the same efficiency when working between the same temperature limits. (2) In the case of the ideal Carnot cycle, using a perfect gas as the working fluid, the efficiency is $(T_1-T_2)/T_1$ where T_1 is the absolute temperature at which heat is taken into the cycle, and T_2 is the absolute temperature at which heat is rejected from the cycle. (3) Therefore no engine, whatever the mode of operation or whatever the nature of the working medium, can transform heat into work with an efficiency greater than $(T_1-T_2)/T_1$. This result cannot be avoided without contradicting the Second Law of Thermodynamics which is one of the most fundamental laws of physics. Thus the maximum theoretical efficiency of the cycle shown in Fig. 1 of Mr. Dimbleby's first letter cannot be greater than $(305\cdot5-304)/305\cdot5=0\cdot5$ per cent and not "nearly 75 per cent," since the cycle is shown operating between the temperatures of 31 deg. and 32·5 deg. Cent. (304 deg. and 305·5 deg. Cent. absolute).

The principal error in Mr. Dimbleby's calculation occurs in taking the specific heat of CO_2 at constant pressure as 0·216—a figure which is approximately correct for CO_2 at atmospheric conditions. However, near the critical pressure and temperature this becomes very much greater and actually at the critical point (or at lower temperatures where liquid CO_2 is evaporating) the specific heat at constant pressure becomes infinite, for heat is then being added without any rise of temperature occurring. The use of the value 0·216 near the critical conditions is therefore quite incorrect.

The chief error in Mr. Dimbleby's second letter occurs in assuming that the Carnot efficiency stated thus:

$$\eta=(P_1V_1\log_e r-P_2V_2\log_e r)/P_1V_1\log_e r$$

is true for all working media, and thence deducing that $\eta=(T_1-T_2)/T_1$ is true only for a perfect gas. In fact, the latter expression is true for all "reversible" engines and the former expression is very far from the truth when applied to a heat engine using a working medium near its critical point.

It is this erroneous reasoning which gives the high efficiencies quoted. Correct theory indicates that the ideal efficiencies of such CO_2 heat engines would be many times lower, and in view of the losses which are inevitable in actual machines, the practical efficiencies would be absurdly small if the engines gave any positive power at all.

P. MCGREGOR ROSS.

Glasgow, W.3, February 13th.

[We regret this correspondence must now cease.—ED. THE E.]

GAS TURBINE DEVELOPMENT IN 1946

SIR,—I have read with great interest your excellent review of progress. In covering such a wide field in which development is taking place so rapidly, it is difficult to be sure of the facts, and there are one or two points where my information differs from yours, and perhaps it would be as well to draw these to your attention. They relate to your issue of January 31st, dealing with developments in the U.S.A.

In the first column mention is made of designs for a rating of 27,000 kW. It seems fairly certain that this is a roundabout reference to the Beznau set, which you mention elsewhere as in construction in Switzerland. From the text it might be inferred that a set of the same size is being designed in the U.S.A., which, I think, is not the case.

At the top of the middle column pulverised coal is stated to be in use. This is rather startling if "use" refers to other than prelim-

inary laboratory experiment. According to published information it has not progressed beyond this stage, which is that reached in Europe in about 1939. The two experimental sets ordered by the Locomotive Development Committee referred to on the same page will be the first to attempt to burn pulverised fuel on commercial lines. It is also stated that plants of the closed cycle type can use practically any fuel. This, I believe, is rather based on hope than on experience, since no closed cycle set has yet been built to burn solid fuel. It may be expected that in the future this issue will be tackled and ultimately brought to success, though the difficulties are likely to be great.

In the third column reference is made to the Pennsylvania Railroad's geared turbine driven locomotive, one of which was in experimental operation since 1944 and two others on order. I think that this must really refer to the steam turbine locomotives described in the *Westinghouse Engineer*, March, 1945.

At one time there was discussion of a gas turbine locomotive in the U.S.A. with hydraulic transmission, but this does not seem to have gone beyond the preliminary project stage, and all gas turbine locomotives reported as at present being designed will use electric drive.

A. Wood.

Twickenham, February 11th.

BURNING SLACK ON OPEN HEARTHS

Sir,—A problem to which combustion engineers might profitably pay attention is that of burning slack on domestic grates. There must be thousands upon thousands of tons of fine coal on the floors of English coal cellars and the piles increase daily as more and more fines are delivered with lumps.

Failing the production by chemists of a cheap and simple bonding material it would seem to be up to engineers to find other means of consuming usefully this now wasted fuel.

The primary need would appear to be some simple device for keeping the fire open, for the effect of slack is to smother it. Another line of attack would be to design a set of riddles that would mix small coal—say, half-inch cube—in the proper proportion with the slack to ensure that both would burn together.

Engineers may have found out in their own homes a solution to the problem and it would be an advantage to their brother engineers and to the public to know what it is.

We have to look forward to several coal-short winters, and there can be no doubt that the burning of slack in open fires and ranges would effect an important economy.

Is not this a matter for the Coal Utilization Council ?

Prior Lien.

RAILWAY ROLLING STOCK

Sir,—Much of the argument for and against the proposed nationalisation of Britain's railway system hinges on whether or not the result would be a better service to the public, whether as passengers or as shippers of merchandise and freight. So far, however, no very tangible policy, on which judgment can be given, has been announced by either side, beyond vague references to "improvements," "accelerations" and similar nebulous aims. In no department of the railways, be they nationalised or privately managed, is the need for a definite and factual policy more real than in that dealing with goods rolling stock.

I estimate that no less than 90 per cent of the goods rolling stock, including private owners' wagons, running to-day shows no noticeable improvement in size, tare/load ratio, suitability for its work, or "operatability" on those running fifty years ago. Indeed, the only difference in design and construction of that 90 per cent is in the final complete adoption of spring buffers and in the partial application of steel underframes, oil-lubricated axle-boxes and rolled steel wheels. The result is that, as the speed of a convoy is that of its slowest ship, the other 10 per cent of the stock, improved as it may be, has to jog along at the safe speed of the 90 per cent.

Let nobody imagine that I advocate the immediate and total replacement of British goods rolling stock by high-capacity bogie vehicles, after the American model. Nothing could be less suited to the special conditions applying to general load carrying in these islands. But surely it cannot be denied that it is sound and economical policy to adopt the high-capacity wagon for specialised purposes where its features are most useful—for coal, coke, iron-ore, &c.

Many power stations, dependent on rail-hauled supplies of coal, are being built, extended, or modernised. Their coal requirements are very considerable. Is it the railways' policy to bring their coal in ridiculous 13-ton wagons, needing the installation of a wagon tippler, or is the L.M.S. system of bringing coal to its Stonebridge Park station in 40-ton bogie hopper wagons, specially built and vacuum fitted, to be offered instead ? It is very clear which is the most economical proposition, in haulage, unloading, siding accommodation, and wagon turn-round, yet no provision for such stock appears to have been made in current wagon-building programmes.

It is agreed that much improvement and mechanisation of the coal-handling facilities at pitheads is necessary in the near future. On what basis are these facilities to be laid out ? Are they to be designed for 11-ton and 13-ton wagons and for some of the new 16-ton wagons, or is the G.W.R. system of encouraging the use of 20-ton wagons by rate concessions to be extended ? Railway loco coal amounts to some 7 to 8 per cent of Britain's total coal production. Is the limited supply of 20-ton wagons for its carriage to be increased, are larger wagons, such as 40-ton bogie hoppers, to be used, or shall we continue to see clanking trains of 13-ton wooden wagons pushed in the usual archaic way over coaling plant hoppers and hoists ?

The iron and steel industry is planning modernised, high-capacity plant on an unprecedented scale. Is anyone planning similarly to modernise the rolling stock for the handling of iron-ore and coke to these plants? For both these traffics, 20-ton, 4-wheeled, and 40-ton bogie hopper wagons seem the ideal choice. Are the steel companies to be encouraged to lay out their sidings and handling plant to take such vehicles ? Nothing seems to be being done yet in this direction.

The whole question of policy in these matters is, of course, closely linked with the survival of the privately owned wagon, which is probably the main reason for the continued use of the loose-coupled, unbraked, goods train, ambling along at a "safe" speed of not more than 20 m.p.h. starting and stopping with painful caution, and causing numerous accidents either through parting or inability to stop, or combinations of both. Is it not time that policies were formulated and announced on the highest level, and worked to, for the early abolition of the private owner's wagon, so often of obsolete design and in decrepit condition, and for the compulsory use of the continuous automatic vacuum brake on all rolling stock, commencing with the compulsory piping of all stock ?

Linked up with this is policy with automatic couplers. Employers whose products entail disagreeable occupations are worried over the reluctance of men to enter such jobs, and the railway shunter comes very much within this category. His work is essential but dangerous. Is the safety record of the automatic coupler, on the road and in the yard, to be ignored for goods traffic (and indeed on certain railways for passenger stock) for ever ? Even if there is no likelihood of its adoption for the next twenty-five years, surely now is the time to make a start with the provision on all new rolling stock of underframes suitable for its fitting. Very few can be really suitable at present. Is the old argument of cost to be trotted out again?

Adequate planning now will reduce cost in the future.

So far, I have not seen a single one of my questions answered by any authority except by a silence which implies that nothing is to be done and that everything will be allowed to muddle on as before. I sincerely hope I am wrong, but see nothing to justify such a hope. Is this the way that improved services to the public are to be brought about ?

Progressive.

Toll Gate, Near Burton-on-Trent,
February 13th.

INCENTIVES IN INDUSTRY

Sir,—I have read with great interest the report on the Government's "Economic Survey of 1947," published as a White Paper.

Two points struck me very forcibly—(i) "To get all we want, production would have to be increased by at least 25 per cent. This is clearly impossible in 1947." (ii) "Encouragement of incentives to increase output throughout industry by bonuses or other methods."

In my opinion the answer to item (i) is found in Item (ii). After approximately twelve years' experience as a time and motion study engineer I have found that there is only one way to get production and that is by giving the operator at the bench or machine an incentive, whereby, for that extra effort the wage packet at the end of the week will be considerably larger. This incentive system must be "put over" in such a way that it dismisses from the operator's mind any suspicion against "incentives" that are most assuredly there at the moment.

Last May I took up an appointment with a firm of radio component manufacturers to take over the task of introducing time study into their organisation. At that time all operators were receiving a lieu bonus of 3d. per hour, representing approximately 12s. for a full 47-hour week. The production as shown in units was 102,123 for the month of May. After about six weeks I started to issue rates for various jobs. The operators were suspicious. They were of the opinion that it was just impossible to achieve our target, but after a month of "educating" these people into the "mysteries of time study," I succeeded in my efforts. Our monthly production units from August have been as follows: August 174,822, September 198,390, October 262,971, November 282,233, December 239,061, January 281,044.

From these figures it will be seen that we have greatly surpassed the 25 per cent increase called for in the White Paper, in fact this increase is approximately 180 per cent against our previous output, with an increase in man-hours of approximately 20 per cent.

As far as the operators' bonus is concerned, where in the past they used to receive their 12s., now a fully experienced operator earns anything from 35s. to 50s. per week. After a while I was able to introduce an efficiency bonus whereby when an operator who reached, for example, 150 per cent over the week, received an additional 2d. per hour.

The foregoing is set out to prove that a good system of time study introduced into industry would go a long way to overcome our production troubles of to-day, and the cry would not be so much manpower as raw materials. The workers

must be given the incentive to produce the goods, but managements must also be brought into line. There are, as we know, firms that have been in operation for years still producing as they were twenty or thirty years ago. These people must be made to realise the country's needs and produce more and more, not just go along in the same sweet way.

It is fantastic to think that ceramic piece-parts ordered now will be delivered in November 1948, but I assure you that this is true.

To assist in this great production drive I would like to see two modifications in P.A.Y.E.

(i) Overtime pay should be exempt from P.A.Y.E. This would induce workers to forget, for the time being, their claims for a 40-hour week.

(ii) I should also like to see bonus earnings exempt from P.A.Y.E. This would encourage operators to go all out in the knowledge that they will gain to the utmost.

H. MIGLIORI.

Barkingside, February 25th.

NATIONAL DIPLOMAS

SIR,—The National Diploma and Certificate courses provided for non-matriculated engineering students in technical colleges have been extremely useful in augmenting the supply of qualified engineers since the inception of the scheme over twenty years ago.

As one who is responsible for certain classes catering for these awards, I find that a proportion of adult ex-Service students as well as younger ones are having to repeat "certain" subjects in order to obtain adequate attendance records to comply with the National Diploma regulations. Many of these students obviously think that their progress is being hampered unfairly, and there is a tendency to demand that a lecturer should take them through third-year work, although they may be in a second-year class. If their demand was complied with, the ultimate result would probably be chaos.

May I suggest that the present post-war conditions now obtaining in many technical colleges warrant some modification to the existing National Diploma and Certificate regulations, so as to reduce the amount of useless class attendance which is now becoming apparent and also reduce the expenditure on needlessly long Government grants, in the case of students who really only require the final year of a course.

I would point out that university degree students do not have to produce an attendance record, yet a degree is usually accepted as being a higher standard of professional ability.

Other members of the teaching profession may have had similar experience to that which I have briefly outlined.

TECHNOCRAT.

London, March 7th.

OVERTIME IN THE DRAWING-OFFICE

SIR,—Coming from one who for some years earned his living as a draughtsman, possibly the deductions from my personal experience may be of some interest.

In the first place, I would say without hesitation that a draughtsman engaged on design work who does eight hours' work a day for five days a week has done an excellent week's work. The operative clause is that he does do eight hours' work a day, not four hours' work, and four hours' gossiping, tea-drinking and mooning around the plant.

I was for some years, away back in the dark ages before the 1914 war, superintendent draughtsman in a fair-sized D.O. which "worked" a 9½-hour day, 7 to 8.30, half-hour for breakfast, 9 to 1, an hour for lunch, 2 to 6, and 7 to 1 p.m. Saturdays. I knew no work was ever done between 7 and 8.30 (I did none myself) and I also knew that the week's output per man was far smaller under this system than it was in the D.O. in which I had previously worked where the hours were 40½ per week.

I am quite sure that not only does overtime in the D.O. not pay (other than as a purely temporary emergency measure) but that it is costly and apt to lead to general inefficiency and a disgruntled personnel. Consider a specific example: suppose an office with a normal day of eight hours and a five-day week working two hours overtime three nights a week. Within a week or two all the occupants have conditioned themselves, maybe quite subconsciously, to turn out 40 hours' work in 46 hours, and there is always the risk of the quality of the work done in the overtime falling below par.

Continuous overtime, in my judgment, is uneconomic in every way. Settle reasonable hours, not more than 40 per week, and provide supervision that will get 40 hours' reasonable work out of the draughtsmen; you will have a happier and more efficient office under such conditions than by any other means I know. If you do have to work overtime, keep it down to the barest minimum necessary and pay well for it.

K. N. HARRIS.

Wealdstone, February 12th.

SNOW

SIR,—The recent photographs in the Press of railway lines and roads blocked by snowdrifts, prompts me to suggest a remedy which would save railway companies and county councils thousands of pounds and the travelling public and industry much loss and inconvenience.

Observation of recent snowdrifts shows that the question has not been given much thought by authorities concerned, yet most snowdrifts have an obvious physical cause which in many instances can easily be removed.

It is well known that drifts occur on the leeward side of an obstruction, or where wind currents, sweeping round an obstacle, or between two obstructions, cause an eddy, and the resultant wind velocity in the prevailing direction is reduced, thus causing snow to be deposited. It is analogous to silting in rivers and estuaries, or to shifting sand in the desert.

In spite of this knowledge, I have seen railway lines and roads completely blocked by snow, which has piled up on the leeward side of a hedge, whilst, where the hedge gave way to an open fence, the road was quite clear. Again, where the wind issued with increased velocity through a gap in some line of obstructions a drift was formed on the leeward side, owing to reduced velocity after passing through the gap.

I suggest, in the interests of the Public, that much valuable knowledge would be gained by making the whole question the subject of scientific study—if necessary with scale models, in a wind tunnel, using pumice dust, or similar light material, to take the place of snow.

By this means will be discovered what obstructions should be removed or others that should be erected (*e.g.*, trees to act as windbreaks, etc.), thus controlling the wind eddies and either eliminating the deep drift at a particular locality or causing it to be formed clear of the road or railway line.

For purposes of experiment and investigation only easterly winds between North and South need be considered, and only sites which have been repeatedly subject to snowdrifts in the past.

By this means one can be reasonably certain of reducing many habitual drifts to proportions with which traffic can cope without hindrance.

As to the cost of such an investigation and any control works it was decided to undertake, such cost would be a fraction of the loss incurred by the country in one snowfall alone, such as we have recently experienced.

It would be interesting to hear if any of your readers have been thinking along these lines, or if any such investigation has taken place in the past.

B. W. ABBOTT.

Cambridge, February 13th.

ATOMIC ROCKET

SIR,—Your editorial concerning my paper on "Rocket Propulsion" has just come to my notice, and I would like to comment on the points raised.

The figures you quote for frictional heating of rockets are quite misleading. As Perring pointed out in his R.Ae.S. lecture, re-radiation greatly reduces the temperature reached by the rocket casing. The calculated stagnation temperature for V-2 was 1100 deg. Cent., but the temperature attained in practice was about 600 deg.

Though the problem is serious for very high speeds, it only arises during the rocket's descent, which means that for some applications rocket braking must be used before the machine re-enters the atmosphere. Frictional resistance would, of course, be absent on interplanetary voyages where there is no physical limit to speed (apart from relativity effects!).

Nor is it correct to say that, above the atmosphere, solar radiation would bring the whole rocket up to boiling point. This would be the temperature of the sunlit side of a black body. Thermal equilibrium can be reached at any desired temperature by giving the rocket's surface a reflecting finish.

I wish, however, to reserve my main criticism for your writer's extraordinary attitude, which can only be called anti-scientific. If he disapproves of attempts to develop new means of propulsion, he should, if he is to be logical, disapprove equally of gas turbines and aeroplanes whose potentialities for destruction are at least equal to those of the rocket.

Attacks of this nature were no doubt made, in almost identical terms, upon the aeroplane itself at the beginning of its career. The belief that technical progress is bad—that wars are started by machines, not by men—is to-day very popular in certain quarters. But one hardly expects to find it among engineers, or propagated in an engineering journal.

ARTHUR C. CLARKE.

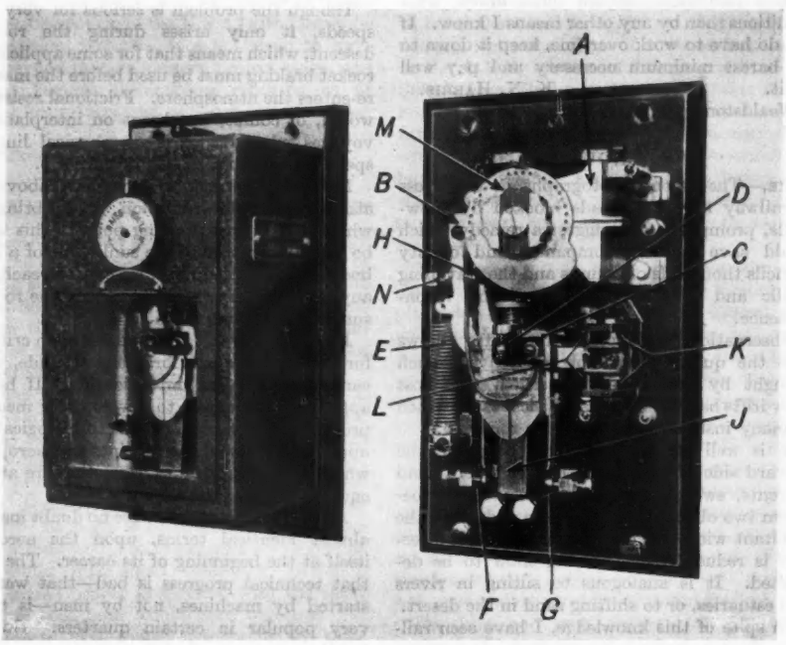
London, March 5th.

PRECISION ECHO SOUNDING.—We were recently invited by Marine Instruments, Ltd., of London and Glasgow, to witness a film which it has had prepared illustrating the use of the latest type of Hughes high-speed precision echo-sounding recording equipment for hydrographic surveying. This equipment is not of the navigational type, that is to say, it is not intended to be fitted on liners, cross-channel vessels and so forth as a permanent item among their aids to navigation. Its use is primarily for surveying harbours, rivers and estuaries used by shipping, or in connection with civil engineering works for the purpose of obtaining an accurate survey of the bottom. With this as its object, it is commonly fitted in a small launch which makes successive runs over determined courses with the apparatus running continuously. It makes and plots on a graph soundings at the rate of 300 per minute, with an accuracy which, even in soft mud, is claimed to be within ±3in. The equipment is basically designed to operate in depths ranging from zero to 40ft, with a simple adjustment to enable depths up to 480ft to be surveyed. The sound transmitter and receiver consists of an identical pair of nickel magneto-striction oscillators operating at supersonic frequency. After two-stage amplification, the echo signal is passed to an electrolytic recorder by which the graph is produced without time lag. The film demonstrated was produced with the assistance of the Southampton Harbour Board. We learn that Marine Instruments, Ltd., is now prepared to carry out surveying contracts with the equipment when the conditions do not justify its purchase by the customer.

Cone Pivot Voltage Relay

PARTICULARS have been received from Brookhirst Switchgear, Ltd., Chester, of its cone pivot voltage relay. This relay was developed primarily for controlling transformer on-load tap-changing equipment and the output voltage of mercury arc rectifiers. The instrument is, however, generally suitable for the control of any medium which is required to be held accurately within prescribed limits.

The underlying principle of this relay is the balancing of a spring tension by the force of attraction exerted on an iron core by a magnetising coil which is energised by the controlling voltage. Referring to the accompanying engraving, the magnet coil A is energised by the applied voltage and attracts a hollow slotted core which is clamped to the upper end of the spring lever B. The lever B pivots on a pin at one end of the beam C. The complete moving system comprising the core, the lever B and the beam C with their associated contact assemblies pivot about a pair of hardened steel cones resting on the support bracket D.



CONE PIVOT VOLTAGE RELAY

In the balanced position (that is, when the force of attraction of the magnet coil on the moving coil is equal to the tension of the spring E) contacts F and G carried on the beam are both open and contact H is held closed by the action of a compression spring. If the applied voltage rises the core is attracted further into the coil and contacts F are closed, energising the "lower volts" control circuit. Conversely, if the applied voltage falls the spring E pulls the core further out and the contacts G are closed, energising the "raise volts" circuit.

The large mass of the moving system provides inherent damping, by making the relay practically insensitive to 50 cycles per second vibration. Further damping is obtained by a vane which is attached to the moving system and moves in the oil dashpot J. To prevent contact chatter and sparking two hold-on or bias coils are fitted. These magnetise two steel screws K. An extension of the beam C consists of a forked end piece which moves in the air gap between the screws K. When either of the contacts F or G is closed the forked end piece moves towards one or other of the screws K. This movement is limited in either direction by a second pair of brass screws L, which act as stops; the corresponding hold-on coil exerts a biasing pull on the beam, holding it in that position until the prescribed voltage is restored.

Voltage adjustment is carried out by the action of an adjustable magnetic shunt above the coil. This shunt is raised or lowered by the rotation of an equi-angular spiral cam M. The working range of the relay lies within plus or minus 5 per cent of the rated voltage and the value, within this range, to which control is required can be set by rotating the cam. A knurled knob projects through the relay protecting cover, and engages with a slot in the cam, so that voltage adjustment can be done simply and rapidly without disturbing the relay and without having to touch live parts.

Should the voltage applied to the coil fail, the relay is prevented from issuing a "raise volts" impulse which would have the undesirable result of setting the controlled apparatus to maximum volts. Failure of supply allows the spring E to pull the lever B to the left, breaking contact at H and making contact at N. By breaking contact at H the control supply is cut off from the common point of the contacts F and G. The effect of making contact at N is to connect the pillar to the "lower" contact F so that a "lower voltage" impulse is sent out and the controlled apparatus is set to "minimum volts."

Compounding can be arranged if it is considered desirable to compensate for line drop by raising the voltage with increase of load. For d.c. supply compounding can be achieved by providing the main coil of the relay with an extra winding energised from a shunt connected in the outgoing bus-bar. The additional ampere turns act in opposition to those of the main winding, the relay automatically raises the voltage so that the total ampere turns remain constant. Where the relay is used to control the voltage of a mercury arc rectifier the compounding winding can be supplied through a small rectifier working in conjunction with a current transformer on one line of the incoming a.c. supply. With a.c. supply compounding can be achieved by using a current transformer to pass a current proportional to the load through a resistance in series with the relay coil. The resulting resistance drop reduces the current through the relay coil and causes the relay to raise the voltage.

The instrument described above is available, in modified form, as a load limiting relay. As such, it is frequently used in conjunction with a voltage control relay. With this combination the incidence of a short circuit would cause the load-limiting relay to override the "raise volts" impulse of the voltage relay caused by the collapse of voltage. The controlled apparatus would therefore automatically return to the minimum voltage position.

Corridor Composite Carriages for the L.M.S.

THE first post-war programme of 800 new passenger vehicles for the L.M.S. Railway included four types, the last of these being a series of 125 new corridor composite carriages. These vehicles are now being built at the company's Wolverton works and approximately eighty have so far been completed.

The new vehicles are 60ft long and 9ft wide, with seating accommodation for eighteen first-class and twenty-four third-class passengers in a total of seven compartments. Their tare weight is 31 tons 7 cwt. The side corridor is provided with four entrance doors, of which two are at the ends, entrance from the other side being by means of two doors only into the end lobbies. A compartment at each end provides the necessary toilet facilities for each class.

The bogies are of the standard L.M.S. four-wheeled type with 9ft wheel base, having arc-welded frames and tyred rolled steel disc wheels with 9in by 4½in axle journals. Suspension comprises two pairs of helical steel bolster springs with the usual eye bolt and "knife-edge" swing beam mounting, and, over each axlebox, a 5ft semi-elliptic laminated spring fitted with rubber auxiliary springs.

The underframes are of the company's standard design, fitted with shock-absorbing rubber-sprung buffers and the usual articulated draw gear. The framing is fabricated by electric arc welding from standard rolled steel sections and plates. To the underframe a timber floor frame is bolted through rubber cushions, and on this the timber body framing is erected. The floor is made up of two layers of tongued and grooved boards covered with felt and brown linoleum. The teak body framing is covered on the outside by 16 S.W.G. charcoal-finished panels, the body side and end panels being carbon arc welded together to form as few units as possible prior to erection. Roof panelling is of 16 S.W.G. galvanised steel, the panels being arc welded together and to steel roof carlines and screwed to the timber cantrails.

Compartments are steam heated in winter by means of two 3ft gilled tubular heaters of the atmospheric type, one under each seat. Steam heaters provided for the corridor are housed in recesses in the body side and covered by metal grilles.

The new vehicles are ventilated by two roof extractors in each compartment and one in each toilet, with additional ventilation in the compartments and corridor from the sliding lights above the windows.

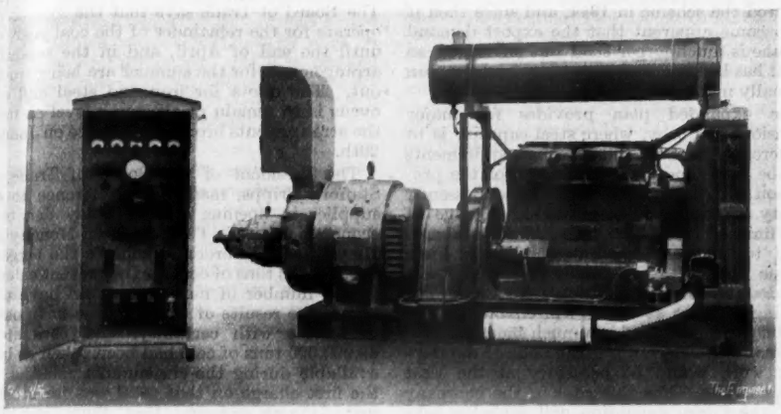
Electric lighting is provided by the company's standard "Wolverton" system. This is a single-battery equipment, the regulator of which combines all the necessary switchgear as a unit. Lighting is by means of 15-watt lamps, of which there are five in each third-class compartment and six in each first-class.

Overhead Line Regulations

IN preparing a revised reprint of the Overhead Line Regulations, designated El. C. 53 (1947 Revise), the Electricity Commissioners have taken the opportunity of incorporating a number of recent amendments. These Regulations differ only from those made by the Electricity Commissioners in 1931 in respect of Regulations 19, 20 and 21. The provision of danger notices and of anti-climbing devices are now dealt with separately under the revised code in Regulations 19 and 20, respectively. Regulation 21 provides that overhead lines constructed in accordance with B.S. 1320, dated August, 1946, will be deemed to comply with the Regulations. The Commissioners have not considered it necessary to revise and reprint the Explanatory Memorandum on the Regulations (El. C. 53A), which was issued in April, 1928, but that memorandum should now be read in the light of the amendments of the Regulations referred to above. Copies of the revised Regulations can be obtained from H. M. Stationery Office, price 2d. net.

Transportable A.C. Welding Sets

ELECTRIC welding is now recognised to be so important for engineering construction and repairs in the field that, when a mains supply is not available, it is becoming common practice to obtain electricity from a transportable generating set. Uusally direct current is employed for welding work in the field, but it is interesting to learn that six sets recently supplied by the Associated Equipment Company, Ltd., of Southall, Middlesex, to the Iraq Petroleum Company, Ltd., are designed to generate alternating current for feeding multi-operator welding equipment. These sets will be used in the Iraq oilfields for such work as the erection of welded oil storage tanks and the weld jointing of pipe lines.



A.C. WELDING SET AND CONTROL CUBICLE

As shown in the accompanying illustration, the welding set is self-contained, comprising an oil engine and a direct-coupled alternator mounted on a fabricated steel bed-plate, together with a 56-gallon fuel tank, starter battery and exhaust silencer. Each set embodies an A.E.C. six-cylinder, 9·6-litre "Comet" Mark III oil engine of 120 mm bore and 142 mm stroke, with a continuous rating of 100 b.h.p. and an overload rating of 112 b.h.p., both at 1500 r.p.m. At full load the fuel consumption is 4¾ gallons per hour. This engine was specifically chosen to permit complete interchangeability of working parts with the engines fitted to seventy-eight A.E.C. six-wheel-drive tractors now being delivered to the Iraq Petroleum Company, Ltd. A C.A.V. "All Speed" centrifugal governor is incorporated in the fuel injection pump. Cooling is by a large-capacity tropical type radiator with oil cooling element, and the air cleaner has been specially developed to suit desert conditions.

The engine is direct coupled to a Crompton Parkinson three-phase, 50-cycle alternator, giving 380 volts between lines and 220 volts line-to-neutral, with a continuous output of 63 kW or 105 kVA at 0·6 power factor. This alternator is a single-pipe ventilated machine with a filter unit, designed for desert conditions, fitted to a machined opening in the top of the end shield opposite the driving end, as shown in the illustration. At the other end the cooling air is discharged to atmosphere through louvred covers in the end shield. The overhung exciter is totally enclosed and is provided with a special shaft extension for a tachometer drive.

The alternator output is taken to a weather-proof sheet steel control cubicle, manufactured by Metropolitan-Vickers Electrical Company, Ltd. This control cubicle incorporates a welding transformer having a delta-connected primary winding and an interconnected-star secondary, to give a four-wire supply for three single-phase, 100-volt arc welders, each of 300 ampere rating. Each welder is connected separately between one line and the earthed neutral, and is provided with a 16·5-kVA condenser for power factor correction. For supplying the welding load the alternator is designed to be unaffected by out-of-balance currents amounting to 50 per cent, so that one phase of the transformer can be fully loaded while the other two phases are on light load.

Provision is made in the control cubicle to allow the alternator output to be used for supplying power and lighting at 380 and 220 volts. When the set operates in this way the output voltage is controlled by a M-V carbon pile automatic voltage regulator, the three-phase multi-operator welding transformer being disconnected.

A Single-Spindle Automatic

WE have received particulars of the new No. 20 single-spindle C.V.A. automatic, which is now being distributed by E. H. Jones (Machine Tools), Ltd., Edgware Road, London, N.W.9. Amongst the features of this machine, the design of which combines versatility with strength and rigidity, are the ample chip space and easy accessibility for tool-setting purposes. It accommodates stock up to 1in diameter in the standard feed finger, an oversize finger being provided for work up to 1¼in diameter, and, if required, an outsize feed attachment can be used to increase the capacity to 1½in.

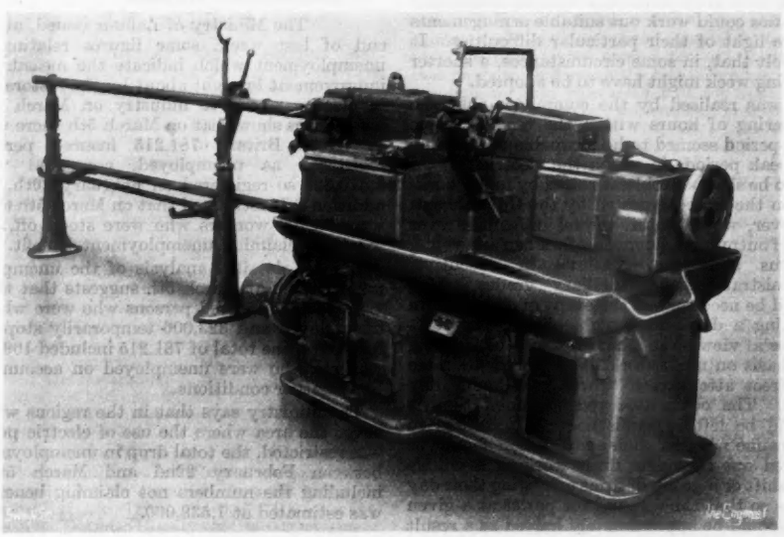
The nitralloy work spindle of the machine is mounted at the front in precision rollers, which run directly on the spindle, and in the rear in angular contact ball bearings. To compensate for journal wear, the front bearings are made adjustable. Set on the spindle, between its bearings, is a brake, which is operated by a clutch on the backshaft. The fitting of this brake is optional, and, whilst it is primarily intended for use in conjunction with special attachments, it is a useful feature when using the machine for chucking second-operation work. The spindle is driven by two roller chains from the gearbox, a double-ended friction clutch on the spindle being used in conjunction with the dual drive to furnish an automatic change of speed or direction of rotation, as required.

A reversible 5 h.p. flange-mounted motor drives the gearbox of the machine. In this gearbox is a double-ended clutch, which, in conjunction with the clutch on the spindle, provides four spindle speed changes under automatic control. By changing pick-off gears in the box, ninety spindle speeds are available in fifteen groups of six speeds, each group consisting of a pair of turning speeds with which either one of two pairs of threading speeds can be employed. When the required speed group has been obtained, selection of the speed ratio is effected by engagement through the friction clutch of one of the two driving chain sprockets. The range of spindle speeds is from 3090 to 37 r.p.m.

The backshaft can be arranged to run at 240, 180 or 120 r.p.m. It is totally enclosed and is made in two parts, coupled end to end, to facilitate its dismantling for servicing purposes. A safety clutch embodied in the backshaft assembly is designed to disengage its drive under conditions of overloading as a result of tool breakage or similar causes. The number of cycle times available is forty-nine, and these range from 3 to 241 seconds.

The turret is designed to accommodate up to six tools, each having a maximum diameter of 4in and a maximum overhang of 6in. The turret slide incorporates a 1¼in screw adjustment and the maximum turret feed traverse is 3in. Trip dogs controlling the turret indexing mechanism are keyed to the rear of the turret camshaft, and this arrangement is designed to eliminate timing errors in indexing. A short front camshaft is enclosed in front of the headstock, and its cams operate the front and rear cross slides, each of which has a traverse of 1¾in with a 1in micrometer screw adjustment for setting purposes.

An automatic cut-out, incorporated in the bar feed gear, stops the machine when the stock is exhausted, and this cut-out is interconnected with a warning light to indicate to the operator when the machine needs restocking.



"C.V.A." NO. 20 AUTOMATIC

Industrial and Labour Notes

G.P.O. Engineers' Five-Day Week

The Postmaster-General has made an agreement with the Post Office Engineering Union, on behalf of the grades it represents, for the introduction of a forty-four-hour net working week on a five-day basis "so far as the public service allows." The agreement, it is stated, has been reached in the light of the Government's White Paper on Economic Policy, and various devices are being adopted to increase output, including the working of longer hours during the summer than in the winter on outdoor jobs.

The Post Office Engineering Union says that between 50,000 and 60,000 Post Office engineering workers of all grades are affected by the agreement, which began to operate on March 8th. The hours of outdoor workers may be increased to forty-five for twelve weeks in the summer and reduced to forty-two and a half for twelve weeks in the winter.

The T.U.C. and Double Day Shifts

Meetings were held last week of the special committee appointed by the Trades Union Congress to examine the problems of the fuel and power crisis and the matters dealt with in the Government's Economic Survey. A statement issued after the first of these meetings said that, after discussing the general situation, the committee directed its attention to the immediate steps which might be taken to spread the electrical power load, and to possible methods of lessening or avoiding peak loads in the present condition of the fuel and power industries.

Proposals were considered by the committee for a shorter working day and week, the staggering of hours, the introduction of night shifts and other arrangements of working time. In view of the urgency of giving guidance on these problems to the affiliated unions, the committee recognised that a certain amount of elasticity would have to be allowed so that industries and localities could work out suitable arrangements in the light of their particular difficulties. It was felt that, in some circumstances, a shorter working week might have to be adopted.

It was realised by the committee that the staggering of hours within the ten or twelve hour period seemed to be incapable of avoiding the peak periods in which the electricity load has to be shed. Problems raised by night working on the scale suggested by the Government, however, would entail special difficulties over loss of output, employment of women and young persons and the personnel in executive, administrative and ancillary grades which would be necessary in the event of a single firm working a day and a night shift. The committee's view was that instead of placing emphasis on night work, it appeared desirable to direct attention to working a double day shift. The committee recommended that it should be left to industries and localities to determine whether such a suggestion should be carried out by single firms working a double day shift or a group of firms arranging their day shifts so that the demand for power at a given time could be approximately halved as a result of some firms working, say, from 6 a.m. to 2 p.m. and the remainder from 2 p.m. to 10 p.m. The actual arrangements of hours and conditions under which they would be worked would be, the committee indicated, a matter for settlement through the appropriate joint negotiating machinery for the industries involved.

Stewarts and Lloyds' Expansion Plan

Schemes for rehabilitation and expansion by Stewarts and Lloyds, Ltd., were included in the report made more than a year ago by the British Iron and Steel Federation to the Minister of Supply. The plan provided for an overall increase of over 25 per cent in the firm's tube-making capacity, with a corresponding increase in steel capacity. Official approval was given to the plan, and construction work is progressing. Stewarts and Lloyds, Ltd., actually prepared the scheme in 1944, and since then it has become apparent that the export demand for tube is much larger than was envisaged, so that it has become necessary to expand the plan originally made.

The expanded plan provides for major extensions at Corby, where steel capacity is to be increased to meet the growing requirements in tube steel, and also to provide for the production of a large tonnage of basic Bessemer quality semi-finished steel. This tonnage of semi-finished steel, it is stated, will be almost equal to that envisaged in the Green Field scheme in the East Midlands, which was included in the Federation's report. The existing facilities at Corby will enable the new capacity to be installed in a much shorter period of time, especially as a great deal of development work would be necessary at the East Midlands site. For this reason, the company says, the Corby expansion will probably take the place of the Green Field scheme in the national plan.

The revised plan has been approved by the British Iron and Steel Federation and has recently been referred to the Iron and Steel Board. The ability to proceed with the work will depend in large measure on the availability of certain major requisites, including the building of houses for the increased number of workers. The plan includes also further extensions, modernisation and alterations in other areas of the company's activities, but the exact form and scope of these cannot be defined until agreement has been reached on priorities and other matters at Corby. Stewarts and Lloyds, Ltd., says, however, that the proposals involve almost doubling its pre-war tube capacity and more than doubling its steel capacity.

Unemployment Statistics

The Ministry of Labour issued, at the end of last week, some figures relating to unemployment which indicate the measure of improvement brought about by the restoration of electric power to industry on March 3rd. The figures show that on March 5th there were in Great Britain 781,215 insured persons registered as unemployed, compared with 1,520,321 so registered on February 26th. In addition it is estimated that on March 5th there were 35,400 workers who were stood off, but were not claiming unemployment benefit.

A more detailed analysis of the unemployment figures at March 5th suggests that there were 458,209 insured persons who were wholly unemployed and 323,006 temporarily stopped. Moreover, the total of 781,215 included 109,940 workers who were unemployed on account of bad weather conditions.

The Ministry says that in the regions which cover the area where the use of electric power was restricted, the total drop in unemployment between February 22nd and March 5th—including the numbers not claiming benefit—was estimated at 1,538,000.

Industry's Coal Supplies

The Board of Trade has announced that steps are being taken to return, for the country as a whole, to the arrangements for allocating coal to industry which originally came into force on January 20th, and to which reference was made in our issue of January 17th. The supplies of coal available for industry, however, other than iron and steel, will not be sufficient to provide a basic quota at the original rate of 50 per cent of requirements together with the original pool.

The new basic quota, therefore, will be at the rate of 33⅓ per cent, but a substantially larger pool will be made available to the Regional Fuel Allocation Committees for supplementing the quotas of specially important industries and undertakings on the same lines as before. The Board of Trade says that the scheme will operate for the remainder of the coal year, i.e., until the end of April, and in the meantime arrangements for the summer are being worked out. The quota for iron and steel and coke ovens is to remain at the same level as under the arrangements brought into force on January 20th.

The President of the Board of Trade, Sir Stafford Cripps, made some reference to coal supplies in opening the three-day debate on economic affairs in Parliament on Monday last. He said that in order to achieve the target of 200,000,000 tons of coal for the present calendar year a number of measures would have to be taken, the results of which it was not possible to foresee with certainty. An estimate of 89,000,000 tons of coal had been taken as being available during the six summer months, and the first charge on that total was for stocking up. It was expected that there would be 5,000,000 tons of stocks to start with, and it had been decided that the best that could be done was to increase the stock figure to 15,000,000 tons by November 1st. The coal budget figures, Sir Stafford continued, were therefore as follows:—Stocking up, 10,000,000 tons; electricity, 11,800,000 tons; gas, 9,700,000 tons; coke ovens supplying town gas, 5,200,000 tons; water, 200,000 tons; railways, 7,000,000 tons; colliery consumption, 5,300,000 tons; miners' coal, 2,100,000 tons; merchants' disposal (house coal), 12,800,000 tons; others, 1,200,000 tons; other non-industrial consumers, 1,500,000 tons; Northern Ireland, 1,200,000 tons; coastwise bunkers, 500,000 tons; Service departments, 500,000 tons; miscellaneous, 1,300,000 tons. The total inland estimate, Sir Stafford explained, was 87,900,000 tons, which would be increased to 91,000,000 tons by an addition for exports and bunkers, and reduced to 89,000,000 tons by the deduction of savings brought about by conversion to oil firing.

R.A.F. Craftsmen in Industry

An agreement has now been reached whereby airmen who received wartime training in certain trades and who completed five years' R.A.F. service in their trade are eligible for admission as skilled men in certain engineering and allied civilian occupations. It is explained by the Air Ministry that their admission as fully skilled members of the appropriate trade union is a matter for negotiation between the airmen and the union concerned.

Ex-airmen of some electrical and related Service trades who were not employed in the electrical industry before the war may now join the resettlement section of the Electrical Trades Union if they enter the electrical industry on release. A member's position is considered by the union at the end of twelve months' membership, and if he is found sufficiently qualified he is transferred immediately to the fully skilled section of the union. In certain circumstances the union will take time-served regular airmen into fully skilled membership.

An airman who wishes to join a trade union to enter civil life as a member may now make personal contact with local union officials while serving. Normally, men are only accepted for trade union membership if they are in actual employment at the time of applying, but R.A.F. service is recognised as employment for this purpose.

These arrangements, it should be stated, do not affect the agreement between the Air Ministry and the Amalgamated Engineering Union under which the training received by R.A.F. aircraft apprentices at Halton and Cranwell is regarded as fully equivalent to that given to civilian apprentices in the engineering industry.

French Engineering News

(From our French Correspondent)

PARIS, March 7th

The President of the French Industrial Mission in Egypt has declared that France will participate with England and the United States in work on the construction of the Assuan barrage. He stated that France had proved her competence by recent work on the Génissiat dam on the Rhône, which is three times higher than the Assuan barrage, and also by work on installations at Casablanca. He also pointed out that as France had not suffered from labour troubles as had the United States, she was in a position to deliver goods without delay.

* * *

In addition to the plan for improved production equipment in France, a programme for the whole of the French Union envisages the maximum development of possibilities of production by native populations. This would provide increased personal consumption goods and permit an exchange of agricultural and industrial goods. Agricultural production and forestry naturally takes first place in French Colonial resources, and new intensive cultivation methods are planned. The scheme provides for annual sums of 192 million francs to be spent on agriculture, 52 millions on herds, and 37 millions on forests. Large sums will also be available for mining exploration. Public works to be considered will be, in order of importance, power, rail and river transport, agricultural water supplies, and means of communication. Since Colonial territory is poor in electric power, and the cost of imported fuel is high, an electric plant at Port-Bouet is to be constructed, which will supply 50 million kilowatt-hours a year. Construction may be completed in just over two years, at a cost of 500 million francs. A ten-year equipment plan to provide equipment and telecommunication material will be financed by the Post Office, public works and civil and commercial aviation. Colonial railways are also to be modernised and electrified as far as possible.

* * *

Dredging equipment has been purchased and constructed in order to deepen channels leading to French ports. Bordeaux can now be reached by ships of 8·8 m draught, Nantes 7·7 m, and Rouen 7·5 m. Important work has also been done on the re-establishment of locks, dry docks and wharves. At Marseilles, where the seven dry docks were seriously damaged, they have now been completely restored. The total covered surface has been increased from 566,557 square metres to 714,630 square metres, and the number of cranes at work has been increased from 659 to 800. It is estimated that at the present rate it will take another four years for all French maritime ports to be completely restored.

Considerable work is also being done on improvement of inland water transport. For example, the Lille–Dunkirk connection has necessitated important work which is now being carried out. This involves improving navigation on the Deule au Don canal, widening the Aire canal, reconstructing the approach ramps at the new Saint-Momelin bridge, as well as the establishment of new railway tracks along the canals. Tugs of 1250 tons are to be constructed, which will necessitate the reconstruction of certain locks. A programme is being considered which would link the Ruhr coal basin and the Seine. A coal route is to be created with Lille among its principal ports. A 23-km canal will link Lille with Tournai, and several canals will have to be made deeper and broader. About 500,000 tons of cement and 85,000 tons of steel will be needed for the work.

* * *

The possibilities of underground coal distillation is being considered for the Moroccan coal mines at Djerada. It is possible that a plant will be installed which will be supplied by gas coming from an anthracite seam situated at a depth of 150 m. Tests will show how thermic plants can best be utilised to provide Morocco with power she lacks at present.

Notes and Memoranda

Rail and Road

RAILWAY RECEIPTS.—The traffic receipts of the four British main-line railway companies and the London Passenger Transport Board in the four-week period ended February 23rd amounted to £21,056,000, compared with £25,079,000 in the corresponding period of 1946. Passenger receipts in February totalled £11,515,000; merchandise, £5,634,000; and coal and coke traffic, £3,907,000.

CYCLE AND MOTOR CYCLE SHOW.—The Council of the British Cycle and Motor Cycle Manufacturers and Traders Union, Ltd., has decided that the time and energy required for organising a thoroughly representative cycle and motor cycle show could, under present circumstances, only be secured at the expense of production. It has, therefore, reluctantly decided not to proceed further with the arrangements in hand for a show in 1947.

A NEW AMERICAN GAS TURBINE LOCOMOTIVE.—According to *Railway Age*, a new passenger locomotive driven by a gas turbine, using oil as fuel, is to be built for the Atchison, Topeka and Santa Fé Railroad by the Baldwin Locomotive Works. This locomotive will weigh about 500,000 lb, and is expected to develop 3000 h.p. It will have a 4–8–4 wheel arrangement and will be capable of speeds in the region of 100 m.p.h. Its cost is estimated at half a million dollars,

L.M.S. LOCOMOTIVE DEVELOPMENTS.—Thirty-three standard L.M.S. 4–6–2 express passenger locomotives are to be equipped, as they pass through the works for general repairs, with self-cleaning smoke-boxes, hopper ashpans and rocking grates, such as are already being standardised on the majority of the Company's new locomotives. The fitting of rocking grates will assist in keeping the fire clean when these engines are working long-distance expresses, and will also facilitate their disposal after duty. Twenty of the engines are already provided with ashpans of the hopper type, and this feature will be incorporated in the remaining thirteen engines as a necessary adjunct to the rocking grate. Controls will be provided inside the cabs to facilitate the emptying of the ashpans under varying conditions of operation. The L.M.S. is also to re-equip 366 express passenger locomotives, comprising the whole of power classes 7P, 6P and 5XP, with speed indicators.

Air and Water

SWEDEN'S MERCHANT NAVY.—Recently published statistics show that at the end of 1946, Sweden's merchant fleet consisted of 2065 ships, aggregating 1,708,000 gross tons. During the year, fifty-eight vessels of over 150,000 gross tons were built for Swedish owners in Swedish yards, and fifty-four ships, aggregating nearly 40,000 gross tons, were sold abroad.

F.I.D.O.—The Parliamentary Secretary to the Ministry of Civil Aviation has indicated recently that no decision can be taken about the installation of F.I.D.O. at the London or other civil airports in the United Kingdom until the results of investigations now proceeding are known. Further research into the development of F.I.D.O. is being undertaken, and a delegation from this country is to visit the U.S.A. to examine work being carried out there. Meanwhile, the Parliamentary Secretary reported, the installation at Blackbushe, which has been on a care and maintenance basis, is being overhauled and will be made available as soon as practicable.

THE PORT OF KARACHI.—The Karachi Port Trust has recently published a well-produced booklet, compiled by Mr. David B. Brow, M. Inst. C.E., Chairman of the Trust, entitled "The Port of Karachi: Outline History of its Development, 1843–1945." It is illustrated by four coloured plans of the harbour as it was in 1838, 1873, 1914 and 1945, and by a number of statistical diagrams indicating the development of trade through the port. When Sind was occupied by the British just over one hundred years ago, the port of Karachi consisted of an anchorage only, three miles from the mainland along a narrow channel not navigable at low tide by even small boats. But by 1945 facilities had increased to such an extent that the total exports and imports reached a record figure of 2,800,000 tons, giving an average daily figure of 7800 tons, including holidays and days when the weather brought work to a standstill. The provision of a dry dock and the development of Karachi's marine airport are matters to which Mr. Brow refers as forming schemes to which the Trust is giving attention.

Miscellanea

TIN PRICES.—The Ministry of Supply announces that until further notice its buying prices for Malayan and Nigerian tin remain unchanged, *viz.*, for Nigerian concentrates £357 10s. per ton of tin in ore at Nigerian port, and for Malayan metal £370 per ton at smelters' works (Penang or Singapore).

CHINA'S STEEL OUTPUT.—Chinese steel output this year is expected to be more than sufficient to meet the country's domestic requirements, according to a statement by the vice-chairman of the National Resources Commission. He also said that factories in Mukden would make 800 railway coaches during 1947, and that the Anshan steel works, the biggest in China, would shortly resume operations.

CONGRESS OF PURE AND APPLIED CHEMISTRY.—The XIth International Congress of Pure and Applied Chemistry is to take place in London, from July 17th to July 24th, the week during which the Centenary Celebrations of the Chemical Society are to be held. The delegates to the International Congress will assemble on Wednesday, July 16th, and the succeeding days will be occupied by a series of technical meetings and social functions. Full details of the Congress may be obtained from the Hon. Organiser, Mr. F. J. Griffin, 56, Victoria Street, London, S.W.1.

WORLD ENGINEERING CONFERENCE.—The Executive Board of the World Engineering Conference is shortly to hold a meeting in Paris. In addition to British and French members, it is expected that representatives will attend from the U.S.A., Switzerland, China, Poland, Egypt, Czechoslovakia and India. Amongst the matters to be considered are the next Congress, the co-ordination of foreign visits, exchange of engineers, students and teachers, information services, international standards of professional qualifications and a technical comparative survey of British and French plans for reconstruction and modernisation.

COMPOSITE ANGLE TOOL BITS.—A new range of tool bits has been introduced by James Neill and Co. (Sheffield), Ltd., in which the ends are bevelled to form a composite angle. The preforming of this angle reduces to a minimum the time normally taken and the material wasted in clearance grinding square-ended bits. These bits, known as the "Eclipse H 3," are made from cobalt super high-speed steel. Their ends have a side top rake and a front clearance of 16 deg., the composite angle making them adaptable for use as either right or left-handed tools. All grinding that needs to be done on the bits before use is that required to form side relief and top rake when necessary. The new bits are available in the following sizes:—$\frac{1}{4}$in square, 2in long; $\frac{1}{2}$in square, $2\frac{1}{2}$in long; $\frac{1}{4}$in square, 3in long; and $\frac{1}{2}$in square, 3in long.

INSTRUCTIONAL WELDING FILMS.—The British Oxygen Company, Ltd., recently gave a preview of two new instructional films on welding to a large audience of representatives of training colleges and Government and Service training establishments. The new films are entitled "Elementary Oxy-Acetylene Welding" and "Advanced Welding Technique." Both are sound films and their presentation is accompanied by an excellent commentary which gives a clear and detailed explanation on all aspects of the various processes. These two additions to the already comprehensive film library of the company bring it up to date with the latest practice, and should prove a valuable supplement to all establishments concerned with the training of welders. We understand that copies of the first-mentioned film are now available for loan, whilst copies of the second one will be ready in a few weeks' time.

DESULPHURISATION OF IRON.—A joint meeting of the Institute of British Foundrymen and the Iron and Steel Institute will be held on Wednesday next, March 19th, at 4, Grosvenor Gardens, London, S.W.1, when the desulphurisation and dephosphorisation of cupola iron and pig iron will be discussed. An invitation to the meeting is extended to staffs of member firms of the British Iron and Steel Research Association. On the following day, Thursday, March 20th, a meeting arranged by the Iron and Steel Institute and the British Iron and Steel Research Association will be held at 4, Grosvenor Gardens, for discussions on side-blown converter practice. Members of the Institute of British Foundrymen are invited to attend this meeting. The morning sessions of both meetings will open at 10.30 a.m. and the afternoon sessions at 2.15 p.m. A buffet luncheon will be served each day from 12.45 to 2.15 p.m. (tickets 6s.).

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, March 18th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Electrical Equipment of a Modern Liner," C. P. Harrison. 6.15 p.m.

Bradford Engineering Society

Monday, March 17th.—Technical College, Bradford. "Heat Treatment Furnaces," D. C. Gunn. 7.15 p.m.

Derby Society of Engineers

Monday, March 17th.—School of Arts, Green Lane, Derby. "Underground Derby." M. L. Francis. 7 p.m.

Institute of Economic Engineering

To-day, March 14th.—Cowdray Hall, Henrietta Place, W.1. "Economic Aspects of the Layout of a Plating Shop," H. Cann. 7 p.m.

Institute of Marine Engineers

To-day, March 14th.—Connaught Rooms, W.C.2. Annual Dinner. 6.30 p.m.

Tuesday, March 18th.—JUNIOR SECTION: The Polytechnic, Scarbrook Road, Croydon. "Combustion Turbines," J. Calderwood. 7 p.m.

Tuesday, March 25th.—85, The Minories, E.C.3. "Dryness of Steam and Priming in Marine Boilers," Com. (E) L. Baker, R.N. 5.30 p.m.

Friday, March 28th.—85, The Minories, E.C.3. Annual general meeting. 5.30 p.m.

Institute of Refrigeration

Tuesday, March 18th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Freeze-Drying," R. I. N. Greaves, and "The Application of Freeze-Drying to Penicillin Production," J. H. Singer. 5.30 p.m.

Institute of Road Transport Engineers, Ltd.

Thursday, March 20th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2. "Carburation," L. J. Spencer. 6 p.m.

Wednesday, March 26th.—MIDLANDS CENTRE: Chamber of Commerce, New Street, Birmingham. "Paints for Road Transport," A. E. Thursby. 7 p.m.

Institute of Welding

Friday, March 21st.—S. LONDON BRANCH: Technical Institute, Gravesend. "Detailed Design of Arc Welded Components," M. Riley. 7.30 p.m.

Institution of Chemical Engineers

Saturday, March 22nd.—N. WESTERN BRANCH: College of Technology, Manchester. "Purification and Azeotropic Dehydration of Acetonitrile," H. R. C. Pratt. 3 p.m.

Institution of Civil Engineers

Tuesday, March 18th.—Great George Street, S.W.1. "The New Howrah Bridge, Calcutta: Design," A. M. Ward and E. Bateson; "Construction," G. E. Howorth and H. Shirley Smith. 5.30 p.m.

Friday, March 21st.—BIRMINGHAM ASSOCIATION: Queen's Hotel, Birmingham. Annual Dinner. 6.30 p.m.

Institution of Electrical Engineers

Tuesday, March 18th.—N. MIDLAND CENTRE: The University, Leeds. "The Generation and Wholesale Distribution of Electricity," J. Hacking. 7 p.m.

Wednesday, March 19th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "Velocity Modulation Valves," L. F. Broadway, C. J. Milner, D. R. Petrie, W. J. Scott and G. P. Wright. 5.30 p.m.

Saturday, March 22nd.—N. MIDLAND STUDENTS: Corporation Electricity Department, Whitehall Road, Leeds. "The Place of the Engineer in the Post-War World," Sir Arthur P. M. Fleming. 2.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, March 18th.—39, Elmbank Crescent, Glasgow. "The Standard Partially Fabricated 10,000 ton Tramp Vessel," J. Lenaghan; and "Coasters and Small Craft in the Wartime Merchant Shipbuilding Programme," J. Lenaghan and T. W. Davis. 6.30 p.m.

Institution of Mechanical Engineers

To-day, March 14th.—Storey's Gate, St. James's Park, S.W.1. "A Contribution to the Solution of the Gas Turbine Problem," A. J. R. Lysholm. 5.30 p.m.

Friday, March 21st.—Storey's Gate, St. James's Park, S.W.1. "The Combination Torque-Converter and Fluid-Coupling Drive," B. J. Tams and A. L. Gatiss. 5.30 p.m.

Saturday, March 22nd.—GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1. Exhibition of Cinematograph Films. 3 p.m.

Monday, March 24th.—GRADUATES' SECTION: Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Three papers on "Hydro-Electric Power Schemes." 7 p.m. (Joint meeting.)

Friday, March 28th.—Storey's Gate, St. James's Park, S.W.1. "The Norwich Heat Pump," J. A. Sumner, and "The Air Cycle Heat Pump," T. F. T. Thomas. 5 p.m.

Institution of Mining and Metallurgy

Thursday, March 20th.—Geological Society, Burlington House, W.1. "Results of Magnetometric Survey at Benallt Manganese Mine, Rhiw, Caernarvonshire," A. W. Groves, and "The Treatment of Gold Ore Containing Pyrrhotite at the Sub Nigel, Ltd.," A. King, A. Clemes and H. E. Cross. 5 p.m.

Institution of Municipal Engineers

Monday, March 31st.—W. MIDLAND CENTRE: James Watt Institute, Birmingham. "The Birmingham Water Scheme." C. A. Rishbridger. 6 p.m. (Joint meeting).

Institution of Post Office Electrical Engineers

Wednesday, March 19th.—Faraday Building (South Block), Knightrider Street, E.C.4. "A Review of Compressed Air Technique and its Practical Applications," W. J. Ford. 5 p.m.

Institution of Structural Engineers

Thursday, March 27th.—11, Upper Belgrave Street, S.W.1. "Stress Distribution in Steel Portal Frame Knees," A. W. Hendry. 6 p.m.

Junior Institution of Engineers

To-day, March 14th.—39, Victoria Street, S.W.1. "Fuel for Industry—Coal to Oil Conversion," J. Duguid. 6.30 p.m.

Friday, March 21st.—39, Victoria Street, S.W.1. Discussion: "Furnace Practice." 6.30 p.m.

Monday, March 24th.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. Presidential Address: "The Spotlight on Production," A. Roebuck. 7 p.m.

Wednesday, March 26th.—N. WESTERN SECTION: Engineers' Club, Albert Square, Manchester. Presidential Address: "Inspection," A. W. Sproull. 7 p.m.

Friday, March 28th.—39, Victoria Street, S.W.1. "An Engineer Visits Sweden," Hubert J. N. Riddle. 6.15 p.m.

Keighley Association of Engineers

To-day, March 14th.—Devonshire Buildings, Devonshire Street, Keighley. "Radar," W. S. Stuart. 7.30 p.m.

London Association of Engineers

Saturday, March 15th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Anniversary Dinner. 6 p.m.

Manchester Association of Engineers

To-day, March 14th.—Grand Hotel, Aytoun Street, Manchester. Annual Dinner. 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, March 14th.—Mining Institute, Newcastle-on-Tyne. "Structural Investigations in Still Water on the Tanker "Newcombia" R. B. Shepheard and F. B. Bull. 6 p.m.

Friday, March 28th.—Mining Institute, Newcastle-on-Tyne. "Some Gear-Cutting Inaccuracies and their Effect on Gear Loads and Gear Noises," S. F. Dorey and G. H. Forsyth. 6 p.m.

Royal Aeronautical Society

To-day, March 14th.—GRADUATES SECTION: 4, Hamilton Place, W.1. "Developments in Propeller Turbine Engines," G. J. C. Davies. 7.30 p.m.

Thursday, March 27th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The War in the Ether," Air Vice-Marshal E. B. Addison. 6 p.m.

Royal Institution of Chartered Surveyors

Wednesday, March 19th.—12, Great George Street, Westminster, S.W.1. "The Legal Obligations of a Quantity Surveyor," E. J. Rimmer. 5.30 p.m.

Monday, March 31st.—12, Great George Street, S.W.1. "Valuation Problems Affecting Licensed Property," S. Motion. 5.30 p.m.

Royal Institution of Great Britain

To-day, March 14th.—21, Albemarle Street, W.1. "The Character of London's Architecture." A. E. Richardson. 9 p.m.

Friday, March 21st.—21, Albemarle Street, W.1. "Where to Live: A Meteorological Problem," D. Brunt. 9 p.m.

Friday, March 28th.—21, Albemarle Street, W.1. "Eclipsing Variable Stars," Sir Harold Spencer Jones. 9 p.m.

Royal Statistical Society

Wednesday, March 19th.—BIRMINGHAM GROUP (INDUSTRIAL APPLICATIONS SECTION): Chamber of Commerce, 95, New Street, Birmingham. "Some Aspects of Statistical Computing," H. O. Hartley. 6.30 p.m.

Sheffield Metallurgical Association

Tuesday, March 25th.—198, West Street, Sheffield, "Reflections on Wartime Steel Inspection," H. Wrighton. 7 p.m.

Sheffield Society of Engineers and Metallurgists

Monday, March 17th.—Royal Victoria Station Hotel, Sheffield. "The Underground Mechanisation of Coal Mines," J. Sinclair. 6.15 p.m.

Society of Chemical Industry

Thursday, March 20th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Prefabricated Houses: Some Chemical and Physical Problems," H. Rose. 6 p.m. (Joint meeting.)

Societe des Ingenieurs Civils de France

Thursday, March 27th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Reconstruction of the Port of Marseilles," M. Jean Couteaud. 5.30 p.m. (Joint meeting.)

Women's Engineering Society

Tuesday, March 18th.—35, Grosvenor Place, S.W.1. "The Engineering Plant at the Bank of England," J. R. Kell. 7 p.m.

Personal and Business

MR. T. KEITH SYMES has been appointed sales manager of Catalin, Ltd.

MR. JOHN B. PERRETT has been appointed technical manager of Trojan, Ltd.

MR. J. M. MORRIS has been appointed general sales manager of Coventry Climax Engines, Ltd.

MR. R. T. PARDOE has been appointed sales manager of the British Electric Transformer Company, Ltd.

BRIGADIER A. E. M. WALTER has been appointed an Inspecting Officer of Railways in the Ministry of Transport.

DR. A. L. ROBERTS, F.R.I.C., has been appointed Livesay Professor of Coal Gas and Fuel Industries in the University of Leeds.

COLONEL SIR GEOFFREY COX, Dr. P. C. Snow and Sir Edward Wilshaw have been elected directors of the English Electric Company, Ltd.

MR. N. F. ASTBURY, M.A., A.M.I.E.E., has been appointed director of research to the Guest, Keen and Nettlefolds group of companies.

E. H. JONES (MACHINE TOOLS), Ltd., has been appointed sole agent for dust-extraction plant manufactured by Bearfoot and Bryett, Ltd.

VICKERS-ARMSTRONGS, Ltd., has acquired the whole of the share capital of G. J. Worssam and Son, Ltd., manufacturers of bottling equipment and corking machines.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION announces that Mr. R. H. Myers has been appointed head and Dr. A. H. Leckie deputy head of the steel-making division.

THE GENERAL ELECTRIC COMPANY, Ltd., states that the Rangoon premises of G.E.C. (Burma), Ltd., which were occupied by the Japanese, have been restored to the company, refitted and reopened for business.

MR. W. H. CASHMORE, M.A., has been appointed Director of the National Institute of Agricultural Engineering in succession to Mr. S. J. Wright, who has resigned on taking up a commercial appointment in agricultural engineering.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY announces the appointment of Mr. T. C. Copland as superintendent marine engineer, in place of Mr. D. J. Harris, who is retiring. Mr. J. W. Pudner has been appointed to succeed Mr. Copland as marine engineer at Gourock.

MR. E. J. H. JONES, of Associated Equipment Company, Ltd., Mr. A. L. Stuchberry, of the Metal Box Company, Ltd., and Mr. H. S. Holden, of the Brooke Tool Manufacturing Company, Ltd., have been elected to the Council of the Production Engineering Research Association of Great Britain.

TUBE INVESTMENTS, Ltd., announces that plans have been completed for the formation of a new company, T.I. of India, Ltd., to provide a technical advisory service and to develop the group's business in India. Mr. J. D. S. Muirhead has been appointed resident managing director of the new company.

THE ALUMINIUM WIRE AND CABLE COMPANY, Ltd., which was formed recently by the British Aluminium Company, Ltd., Hawker Siddeley Aircraft Company, Ltd., and Tube Investments, Ltd., has arranged to purchase premises at Port Tennant, Swansea, from the Ministry of Supply, and will take possession of them on May 1st. The company's temporary offices are at Salisbury House, Circus Place, London Wall, London, E.C.2.

MR. ROBERT FOOT, chairman of the Mining Association, has resigned the presidency of the Coal Utilisation Joint Council, on the National Coal Board, taking the place of the Mining Association of Great Britain as a constituent member of the C.U.J.C. Mr. J. C. Gridley, marketing member of the National Coal Board, has been elected president for 1947, and Mr. John Charrington, of the Chamber of Coal Traders, has been elected vice-president.

A GOVERNMENT FACTORY at Conway Road, Llandudno, previously used by the Ratcliffe Engineering Company, has now been allocated to the International Refrigerator Company, a subsidiary of Associated Electrical Industries, Ltd. The International Refrigerator Company will use the premises for the manufacture of commercial refrigeration and for certain engineering work to be transferred from other factories belonging to the group.

THE "PEACHE" ENGINE.—In our obituary notice of the late Major Guy Beaumont in last week's issue we referred to the "Pasche" steam engine as having been made at one time by Davey, Paxman and Co. The name was misspelt; it should have been the "Peache" engine.

A Seven-Day Journal

Electrical Generating Plant

THE increased production of electrical generating plant formed the subject of a written reply in the House of Commons last Monday. Mr. Arthur Greenwood stated that the Prime Minister, accompanied by the Minister of Supply and the Minister of Fuel and Power, met representatives of the heavy electrical plant manufacturers and boilermakers on Monday, March 10th, to discuss ways and means of increasing and accelerating the output of electrical generating plant. The manufacturers gave assurances of their fullest co-operation in the measures necessary towards this end. The suggestions discussed at this meeting will be considered by a committee under the chairmanship of the Minister of Supply. In addition to the departments principally concerned, the Electricity Commission, the Central Electriciy Board and the industry will be represented on this committee. A special organisation built on wartime experience is being set up to assist in planning production and in overcoming difficulties. Every endeavour will be made to ensure the necessary supplies of labour and material for the manufacture of heavy electrical plant and boilers and to speed up their production.

The London Association of Engineers

SOME 450 members and guests were present at the annual dinner of the London Association of Engineers, which was held on Saturday, March 15th. Proposing the toast of "The Engineering Industry," Mr. A. Woodburn, Joint Parliamentary Secretary to the Ministry of Supply, drew attention to the considerable assistance being given by the Government to the engineering industry, particularly in the field of research. He thanked engineers for their great efforts during the war, and pointed out that the country now looked to the engineering industry to increase productive capacity in order to overcome the shortage of manpower. In replying to the toast, Sir Charles Bartlett criticised the Government for confusing rather than helping industry, and said that if, without undue interference, industry was given the tools, it would do the job required of it. The health of the many distinguished guests from the Services and industry was proposed by Mr. W. A. C. Newman, who pointed out that the raising of the school leaving age, coupled with compulsory military service, had brought about a new problem for industry. Unless care was taken these two new features would have a disastrous effect on both the trainee engineer and the organisation of engineering industry. In his response to the toast, Field-Marshal Lord Montgomery of Alamein spoke of the debt of gratitude which the Army owed to the engineering industry, both for its great efforts in providing equipment and for the services of the large number of highly skilled men it spared for the Services in time of urgent need. The successful future of the fighting Services was closely allied to planned scientific research and to the engineer fell the task of translating the results of research into practical effect. Reducing the problems which beset the country to their simplest form, he contended that the answer would be found in three things—leadership, team work and hard work.

New Generating Stations for Mid-East England

THE Central Electricity Board has received from the Electricity Commissioners a further amending electricity scheme for Mid-East England providing for three new generating stations, with first sections each comprising an installation up to 130,000 kW of generating plant, to be constructed and become selected stations. In making representations to the Commissioners for the formulation of the present scheme the Central Electricity Board pointed out that the two new selected stations specified in an earlier amending scheme for the area have already been allocated (Mexborough and Skelton Grange, Leeds), and indicated that, as a result of a review of the prospective plant requirements, they had come to the conclusion that it would be necessary to take steps for the establishment of at least three other new stations. Of these, one is proposed to be located on the River Trent in the vicinity of Keadby, and one will probably be required in the west of Yorkshire and the other in the south of Yorkshire to meet the increasing load in later years. Copies of the scheme, entitled "The Mid-East England Electricity (Alteration and Extension) Scheme, 1947," together with an explanatory memorandum by the Commissioners, are on sale at the Stationery Office.

The Transport Bill and "C" Licences

THE Standing Committee of the House of Commons, considering the Transport Bill, was informed by the Minister of Transport on Thursday of last week that the Government had decided to withdraw from the Bill the clauses dealing with class "C" licences. The Minister said that the provisions in the Bill with regard to these licences were, in his view, reasonable. The licences in this category covered over 300,000 vehicles used by firms employing road transport for the carriage of their own goods. After consideration of the difficulties of the present trade situation, the Minister explained, the Government had reached its decision not to proceed, for the time being, with the clauses in the Bill dealing with "C" licences. He went on to express the hope that it would be appreciated that the Government looked upon this gesture as a legitimate and material one, and that it would be taken into account that "C" licences were granted to businesses carrying their own commodities.

Institute of Marine Engineers

THERE was a large attendance of members and guests at the annual dinner of the Institute of Marine Engineers, which was held at the Connaught Rooms on Friday evening, March 14th. In the absence of the President, Sir Amos Ayre, who is now in South America, Sir William Currie, Past-President, occupied the chair. The toast of "The Lord Mayor and Corporation of London" was ably proposed by Señor Don Manuel Bianchi, the Chilian Ambassador, who made reference to the successful visit of a mission of British shipbuilders, headed by Sir Wilfred Ayre, to Chili a year ago. The Lord Mayor, Sir Bracewell Smith, responded. The toast of "Empire Shipping" was fittingly proposed by Mr. W. J. Jordan, the High Commissioner for New Zealand, who expressed his confidence in the future of Empire ships. In his reply, Sir Ronald Garrett, the chairman of Lloyd's Register of Shipping, recalled the recent statement of Sir Ernest Murrant, in his Presidential Address to the Chamber of Shipping, that British shipowners had committed themselves to spend about £230 million, representing some 3,500,000 tons of shipping, by way of purchase and new construction. That was, Sir Ronald claimed, a very remarkable act of faith. At the end of last year the British shipbuilding industry had close upon 2,000,000 tons under construction in British shipyards. That was more than 50 per cent of the world total, and of that total, more than 20 per cent was for foreign ownership, a substantial contribution to our export trade. Another sign of vitality was the growth in recent years of co-operative research organisations within the industry. The toast of "The Institute of Marine Engineers" was proposed by Admiral Sir John H. D. Cunningham, First Sea Lord, who made reference to the far-reaching changes which had taken place in marine engineering development. He said that it was essential that both the Royal Navy and the Merchant Navy should in future get the best and most up-to-date machinery. Oil firing had brought mobility of ships, ability to refuel at sea, and had emphasised the importance of Middle East oil supplies. Sir William Currie, in his reply, said that during the past year the membership of the Institute had increased from 4750 to 5129. It had had the pleasure of welcoming to its membership a number of Royal Navy engineer officers, which augured well for a growing exchange of experience and technical information.

Engineering Firms and the Fuel and Power Crisis

THE Engineering Industries Association states that a number of engineering firms are desperately short of funds and are unable to meet the taxation liabilities incurred through their war efforts. They had relied on steady peacetime production, in order to maintain a credit cash position, but in many cases their hopes have been shattered by the recent fuel and power crisis. They now face a financial crisis owing to loss of production, payment of guaranteed wages, factory maintenance and overhead charges during the period of closing down. These grave facts and the following proposals have been placed before Mr. Dalton, the Chancellor of the Exchequer, by the Association, on behalf of 3000 engineering firms, for his urgent and sympathetic consideration. In making its proposals the Association states that taxation relief alone is not enough. Its effect is delayed and it presents anomalies between different classes of taxpayers. The proposals put forward include special grants for the reimbursement of wages; capital assistance where equipment such as plant had to be provided solely to overcome the effects of fuel and power cuts; taxation relief of capital expenditure, for expenditure of capital for which capital assistance is not available; expenditure of a revenue nature, attributable to the crisis to be treated as rehabilitation expenditure ranking for tax relief; where loss of profits was caused by the crisis it should be recognised that E.P.T. post-war refunds are eligible for making good such comparative diminution; finally, where the payment of E.P.T. liabilities and income tax, 1946–47, is outstanding, the collection should be entirely withheld, pending any re-arrangement of finances necessitated by losses and expenditure incurred as a result of the fuel and power crisis.

The James Watt International Medal

THE Council of the Institution of Mechanical Engineers has unanimously decided, on the recommendation of the Société Suisse des Ingénieurs et des Architectes, to award the 1947 James Watt International Medal to Professor Stepan Prokofievitch Timoshenko, formerly Professor of Theoretical Mechanics, Stanford University, California. The presentation will be made at a general meeting of the Institution at 5.30 p.m. on Friday, April 25th, when Professor Timoshenko will deliver a special lecture on "Stress Concentration and Fatigue Failures," which will deal with certain experimental work carried out in several American laboratories. The medal, it may be recalled, was founded by the Institution in 1936 to commemorate the bicentenary of the birth of James Watt on January 19th, 1736. An award is made every two years to an engineer of any nationality who is deemed worthy of the highest award that the Institution can bestow and that a mechanical engineer can receive. The last award of the medal was made in 1945 to the late Dr. F. W. Lanchester.

The Industrial Crisis and the Prospective National Output of Coal

By SIR RICHARD A. S. REDMAYNE, K.C.B.

IT must be evident to every student of economics that the present industrial crisis is due to an insufficient production of coal from our collieries extending over many months, a crisis the occurrence of which, one would have thought, could have been foreseen and guarded against. True, the climatic conditions prevailing this winter have proved to be severer than normally, but we have witnessed bitterly cold seasons in the past without experiencing any accompanying fuel shortage; the various industrial concerns throughout the country being kept well stocked and there being an ample supply of coal to meet domestic requirements. Nor was the export of coal impeded.

The annual output of coal has shown a more or less gradual downward tendency over a long period of years. The causes for this decline the writer has endeavoured to explain in an article which he contributed to THE ENGINEER in January last. In the present article he proposes to review critically the various suggestions which have been advanced in various quarters for so increasing the output of coal as to allow of the home requirements being met and permit of a satisfactory export.

THE EXTENT OF THE DEMAND

The Government's proposed output of 200 million tons for the present year to meet all the internal requirements of the country is a quite inadequate figure. It was estimated that for the year 1913—the year when our output of coal reached the maximum figure of 287,430,473 tons—that the home requirements, inclusive of bunkers for coasting steamers, were 187,500,000 tons, but since then there has been a great expansion in the demand in respect of heat and light from gas and electricity undertakings—the electric grid was not in existence in 1913. The probability is that the internal requirements of the United Kingdom at the present time will exceed 200 million tons, if every demand is to be satisfied, leaving nothing for export. In the year 1913 we exported 73,400,118 tons—exclusive of foreign bunkers.

NATIONALISATION

Reviewing the various suggestions put forward for remedying the situation, it has been claimed by some that the present state of affairs is due to the delay in carrying into effect the nationalisation of the mines, which, of course, is absurd. They argue that a change of ownership, the taking over by the nation of the collieries from private ownership, would be followed by the advent of an era of peace in the industry—the introduction of a new spirit among the miners—and by the pursuance of a more enlightened and energetic policy in the management of the mines, resulting in enhanced production. So far one cannot say that these predictions have been realised. Nor is this surprising when one considers that no single Royal Commission or Departmental Committee that has been set up to investigate and report on the coal mining industry—and there have been a number—has reported in favour of the nationalisation of the industry, but on the contrary, when the proposal *was* considered it was condemned. Nationalisation *per se* offers no remedy—the aggregation of colliery interests consequent upon nationalisation, though also obtainable without nationalisation, is, however, another matter.

Nationalisation of the coal mining industry means the removal therefrom of three important influences which make for success in any industry, namely, incentive, initiative and personal responsibility. On the other hand, the aggregation of colliery interests—an end which, as has already been said, could also have been secured without resorting to nationalisation—does allow of the carrying into effect of several important remedial measures prohibited to separate units.

Judging from the experience gained in regard to the results of nationalisation of the French coal mines, the outlook from the point of view of an enhancement of output resulting from change of ownership is not hopeful.

From the report of the unbiassed Economic Studies Section of the Sorbonne University on the facts and figures supplied from Government Ministries and each section of the coal mining industry, we learn that whereas the output per man per day for all the mines was, in 1938, 1220 kg, the average for the year 1946 was only 940 kg, and that "during the first quarter of 1946 the loss of output was two and a half times *less* in the non-nationalised mines than in the nationalised mines," and "for the whole of France, absenteeism among men working below surface in the coal mines since nationalisation has increased by 83 per cent, compared with the 1938 figures." Again, as regards finance, "The French coal industry before nationalisation has followed for more than a century a self-financing policy; more than half of the profits were reinvested in the coal mining companies. But, to-day, under nationalisation, there can be no question of such a method. In fact, the cost price of a ton of nationalised mine coal is such that the Treasury is obliged to give a subsidy of 4,000,000,000 francs per year (£8,300,000) to the mines to enable them to sell coal at a price per ton low enough not to upset the market." *Verbum sat sapienti.*

Taking the long view, the aggregation of colliery interests (which was in course of being attained prior to nationalisation), without resorting to nationalisation, does permit of certain improvements being carried into effect, denied to a system of separate units, in that the barriers of coal can, in a number of cases, be worked off, haulages be improved to some extent by centralisation, and, also, in some cases, coal areas be better and more economically recovered; drainage simplified and cheapened, and winding of coal concentrated. Saving in expenditure may also be effected by centralised purchasing of colliery stores and plant, and, possibly, in the better and semi-centralised marketing of the coal. But these are improvements making rather more for the lowering of cost than for the enhancement of output, nor are they likely to be immediately operative.

INCREASE IN THE NUMBER OF PERSONS EMPLOYED

In the year 1938, 802,100 persons were employed at our collieries, with an output of 240·41 million tons of coal. Last year the comparable figures were 696,700 persons* and 189·3 million tons, of which 180·5 were from the mines, the balance being from opencast workings.

The amenities at the collieries are now as good as they were in 1938, the wages earnable about double what they were then, and, compared with the rates payable in other industries, are in a very favourable position, so there should exist no reason, on these accounts, militating against the influx of efficient labour to the mines. But it is face workers, *i.e.*, the actual getters of the coal rather than "transit" hands (*i.e.*, hauliers, shifters and other "offhand" men) who are chiefly required in order to achieve an increase in production, and not every man is suited to this class of skilled or semi-skilled work.

The sources of supply of mining labour have in the past been (*a*)—and chiefly—the sons of miners; (*b*) country-men and others seeking higher wages; (*c*) foreigners, chiefly from European coalfields—there were at one time, some years ago, a few thousands of Poles working at our collieries, largely in Scotland, and very good workers they were, too. The question in this respect that requires consideration and elucidation is to what extent is face-room available at the collieries for the employment of qualified coalgetters? In this connection must be borne in mind the disastrous effect of the 1930 Act in restricting development at existing collieries and in the prevention of the opening-out of new undertakings, with, also, consequential drifting of miners into other branches of industry. What the National Coal Board should have done—and still should do—is to take, in respect of each separate class, a census of its additional requirement (*a*) at present, and (*b*) in the near future, *i.e.*, as to the number and class of workers required for complete staffing of each colliery. We would then know, at least, what is the total that could be employed. It is to be feared, however, that the extent of the face-room will prove to be lower than is generally realised.

There should be no valid opposition on the part of the Miners' Federation to the introduction to the mines of qualified foreign mining labour, whether Poles or others, provided they become members of and are amenable to the precepts of the Federation. Such labour should not be indiscriminately selected but should be such as is suited to a specific class of work. A recruiting station might, with advantage, be established at Area Boards' headquarters in each mining district where the necessary information could be given to intending applicants and men be "set on" to do that class of work which they are best qualified to perform.

ABSENTEEISM AND PROPAGANDA

From the point of view of securing an immediate increase in output, there can be no doubt that reduction in absenteeism—as abstention from work has come to be designated—offers the best of all the possibilities. In the year 1939 (the year of the outbreak of the Great War) the overall absenteeism (surface and underground

* The figure in the White Paper is 695,000, but the figure given here is the average over the year 1946.

workers) was 6·4 per cent; for the year 1946 (the latest annual figure available to me) it was 15·95 per cent, a difference of nearly 9·55 per cent.

The Coal Mining Organisation Committee, established during the first Great War (and in existence from February, 1915, to February, 1917) of which the present writer was Chairman, found, after close investigation, that 5 per cent was a liberal allowance to make over all classes of colliery labour—surface and underground—for enforced absence from work due to sickness, injury and other unavoidable causes; therefore, taking 15·95 (year 1946) as the percentage of overall absenteeism at present ruling, there remains a balance of 10·95 per cent which could be made productive if one and all put in a regular attendance at work. Now 10·95 per cent of the number of persons employed at the mines, *viz.*, 696,700 is equivalent to 76,288, which, multiplied by 267, the output per person employed above and below ground†, gives 20,168,896 tons as the extra quantity which might be obtained were voluntary absenteeism completely to cease. But this is an under-estimate by reason of the fact that the percentage of lost time is greater on the part of the labour employed at and about the coal face (*viz.*, thé coalgetters and putters) than in respect of other classes of underground labour, and considerably so in comparison with the surface labour. In point of fact, the percentage of voluntary absenteeism at the coal face was 16·3 per cent in 1944 and 19·32 per cent in 1946. The deduction for involuntary absenteeism in the case of face workers would have to be higher than the overall average by reason of the more dangerous and arduous nature of the class of work performed by them.

Perfect regularity of attendance at work is not to be expected—it does not come within practicable possibility, but the difference between involuntary and voluntary absenteeism is so great—and remembering that total absenteeism has been as low as 6·4 per cent (1939) if not lower in previous years—that a considerable reduction should be possible with a corresponding enhancement in output.

During the first Great War, there was set on foot by the Coal Control Department (in which the present writer was adviser to the Controller and Head of the Production Section) a coal production propaganda, the Coal Controller as well as the President of the Board of Trade addressing meetings of workmen and officials in the various mining centres, and the President and executive of the Miners' Federation of Great Britain (in execution of their pledge to the Controller that they would do their utmost to increase coal production) issued a manifesto in which they showed to the miners the urgent necessity to the nation for a much greater supply of coal.

On two occasions, also, a national gathering of miners' delegates from every colliery was held in London, the first during the existence of the Coal Mining Organisation Committee, and addressed by the Home Secretary and the Minister of Munitions and others; the second, at a later date, was arranged by the Coal Control Department—which succeeded and absorbed the Coal Mining Organisation Committee—and was addressed by the Prime Minister and other prominent persons. There was set up also, a system of Joint Committees—there was one at every colliery—to enquire into the causes of irregular attendance at work, and also into the reasons for any loss of output which might occur, whether due to irregular attendance or any other cause. Similar courses might, with advantage, be followed at the present time.

† The average for the years 1943 and 1944. The figure in the White Paper is 259, *i.e.*, the figure for the year 1944.

Extra Day's Work

It is much to be doubted whether the opening of the mines for work on Sundays with extra pay to those at work on that day, which has been advocated and is being practised at a number of collieries, will result in any overall beneficial effect. The tendency will be, it is to be feared, towards an increase in absenteeism on the other days of the week for those miners who have, so far, proved deaf to the exhortations of their leaders to work more regularly. They will take advantage of the inducements offered to work on Sunday with resultant further absenteeism from work on the other days of the week. The great majority of the miners are hardworking men who do attend regularly at work, and should have, and indeed, require a Sabbath day's rest; they are not the absentees who comprise the less conscientious and, probably, the younger men—those with less responsibilities. It is doubtful, therefore, whether any more coal will, in the long run, be obtainable from working on Sundays, but it will certainly enhance the cost of production.

There is no doubt that P.A.Y.E. has acted as a deterrent to full attendance at work in that it carries with it an inducement to earn only up to a recognised figure, beyond which income tax is deductable. This is an unpleasant inference to make, but one has heard of miners actually so expressing their feeling on the matter.

Enhanced Mechanisation

Exaggerated views are entertained by many critical speakers and writers on the subject of colliery reorganisation in respect of the possibilities of greater mechanisation of the collieries, and a good deal of ill-informed nonsense is entertained and talked thereon by the ignorant man-in-the-street. As the present writer has shown in the articles on this subject contributed to The Engineer towards the end of the year 1944, mechanisation has been carried out to a very great extent at our collieries. Indeed, so much so that the more modern of them will compare favourably in that respect with any collieries in the world—in fact, very many of our coal mines of old, as well as of modern, origin are very highly mechanised, some of them as regards the mechanical getting of the coal up to 100 per cent. At some like, for instance, the Kent collieries, it does not pay mechanically to cut the coal—it being too tender to stand up to undercutting. At others, as, for instance, many of the Welsh collieries, the coal is so permeated with "breaks" or fissures, that undercutting cannot be attempted without the liability of the machine being buried by coal. At some collieries, too, the roof conditions are such that, in the interests of safety, the roof supports have to be carried right up to the face, which prohibits the face being traversed by a mechanical coal-cutter. In some of these cases, however, pneumatic picks can be, and are, in use. That there has been—in such cases as the conditions permit of it—a great increase of late years in the application of the mechanical aids to labour at our collieries, the official statistics show. Thus the number of mechanical coal cutters rose from 7729 in 1938 to 8292 in 1945, and of pneumatic picks, from 12,923 to 20,557, and of coal-face conveyors from 5623 to 6317, and the horsepower of electric motors from 2,229,000 to 2,552,000. Yet there were 60 million less tons of coal produced in 1946, as compared with 1938, in large measure due to less manpower—a decrease in the labour force and an increase in absenteeism.

One would have thought that the increase in output per manshift worked, calculated over all workers, would, with the great increase in the application of labour-aiding appliances, have shown a more marked improvement, but one of the most disquieting features of recent years at the mines is the falling-off in the production of coal per person employed. Thus, the figures for the six years 1939 to 1945, inclusive, are as follows:—

Year	Output per man-shift worked	Output per person employed per annum
1939 ...	1·14 ...	301·9
1940 ...	1·10 ...	299·4
1941 ...	1·07 ...	295·8
1942 ...	1·00 ...	287·1
1943 ...	1·03 ...	274·5
1944 ...	1·00 ...	259·2

There is no change in regard to natural conditions underground or at the surface to account for this gradual downward decrease over the war years, nor can it be attributed to the withdrawal from the mines of some of the sturdiest of the miners for service in the fighting forces or drafting into munitions, for such subtraction did not take place after the year 1940, and the decline continued steadily thereafter—nor is it due to absenteeism, as the decline in output per manshift shows. Some increase in extension of mechanisation at the coal face may be expected from the introduction of power-loading of coal machines, which is a comparatively recent development, but the application of mechanical cutters has about reached saturation point.

Reorganisation and new Undertakings

The somewhat partial reorganisation possible by reason of the aggregation of colliery units has been already touched upon. The Report of the Reid Committee indicated the lines upon which this might proceed, but the proposals in many respects, even where practicable of execution, will be long in fructifying and most is to be expected from the sinking and development of new undertakings laid out on a large scale and equipped with the most up-to-date plant and machinery. But, as all the shallower areas are already developed, only the coal seams lying at great depth from the surface are available for exploitation; to sink and develop a colliery up to the productive stage, in such cases, is a matter of years for accomplishment—it would take six to seven years at least before such a venture would reach the profit-earning stage. That the sinking and development of new collieries is necessary, nay, imperative, in order to maintain and increase the national output of coal and supply the place of the dying collieries is plainly evident. It is a process which has characterised the industry for centuries, but one which has of late years been hindered by the uncertainty as to the future and the restrictive effect of the 1930 Act.

Conclusions

To sum up the situation. It would appear that some years must elapse before the coal mining industry recovers lost ground—due to the causes which have been set out and explained in the previous article already alluded to—and a substantially increased output of coal is procurable. For a minor

enhancement of output, the more immediate hope is to be found in the reduction of absenteeism and enlargement of the labour force at the collieries.

One thing is clear and that is, that without a substantial increase being forthcoming, industry generally must suffer a setback, for the country's maximum level of industrial production must necessarily be limited by the amount of coal annually available for consumption. Two hundred million tons in 1947 is quite inadequate to support exports reaching up to 140 per cent of 1938 value, unless production for the home market, instead of expanding, suffers a reduction. With a labour force of 802,100 persons, the 1938 figure, and absenteeism at 7 per cent (the figure for 1939 was 6·4 per cent) there would appear to be no reason why we should not secure an annual output of 250 million tons of coal, taking into consideration the considerable advance which has taken place in the introduction of labour-saving appliances during the last few years.

One final and general conclusion forced upon one, from a study of the history of the coal mining industry over the period 1917 to 1947, is that Government interference with the economics of industry does not make for efficiency and is not, therefore, in the national interest.

One hundred and sixteen years ago, Macaulay, in concluding a review of Southey's "Colloquies," used these words :—

"It is not by the intermeddling of Mr. Southey's idol, the omniscient and omnipotent State, but by the prudence and energy of the people that England has hitherto been carried forward in civilisation. . . . Our rulers will best promote the improvement of the nation by strictly confining themselves to their own legitimate duties, by leaving Capital to find its most lucrative course, commodities their fair price, industry and intelligence their natural reward, idleness and folly their natural punishment, by maintaining peace, by defending property, by diminishing the price of law, and by observing strict economy in every department of the State. Let Government do this, the People will surely do the rest."

Wise words, applicable with more than equal force to the present time than when they were first written.

The Institute of Metals

No. II—*(Continued from page 222, March 14th)*

THE following paper was presented by Mr. Forrester :—

THE INFLUENCE OF COMPOSITION ON THE ADHESION OF TIN-BASE BEARING ALLOYS TO STEEL

By P. G. Forrester and L. T. Greenfield

Synopsis

When a tin-base white metal lining is cast on to steel by the ordinary hand-lining method, the quality of the adhesion has been shown to depend on the composition of the white metal. In particular, alloys of high copper content have low bond strengths owing to a tendency for Cu_6Sn_5 to form on the bond. This segregation of Cu_6Sn_5 is due to a combination of directional cooling and of the provision of nuclei for crystallisation by the tinned steel surface, and it may be wholly or partly inhibited by very rapid cooling.

A layer of Cu_6Sn_5 at the bond greatly reduces its resistance to tearing or to impact. Either the chisel test or the test described by Chalmers indicates this type of bond weakness, which is not shown, however, by a pure shear test. A thick layer of $FeSn_2$, formed by prolonged immersion in a tin bath at a high temperature, weakens the bond in a similar manner.

Experiments with tin-antimony-copper-cadmium alloys containing up to 3 per cent cadmium showed that these alloys give good bond strengths when slowly cooled.

Discussion

Mr. P. T. Hollingan (Glacier Metal Company, Ltd.) said there was what he regarded as a very important omission from this paper, in that no mention was made of the composition or the surface condition of the steel used in the test. That was of vital importance, and it was necessary to know, in particular, the carbon and manganese content, and also as to whether the steel was in the hot-rolled or cold-rolled condition. On that latter point depended the efficacy of the pre-treatment given to the steel prior to tinning. If the steel was cold rolled, then the authors' method of pre-treatment was insufficient. He asked if there was any de-wetting and what was the thickness of the test piece in the as-cast condition. This latter had a marked effect on the bond strength as far as the influence of contraction stresses on the bond was concerned, and might cause a local bond fracture during the cooling process. Referring to the importance of load carrying capacity of white metal lined bearings in service, he suggested there were very good reasons for using white metals with varying copper content, and it was necessary sometimes to use a fairly high copper content by virtue of considerations of mechanical properties of the white metal lining itself, particularly in the case of a thick white metal lining where it was necessary to have adequate compressive strength. At the same time, the authors had underlined, quite rightly, the importance of keeping the copper content as low as possible consistent with these other considerations. He was pleased the authors had underlined the importance of what they called dynamic adhesion tests. He agreed that the static tensile test, whilst valuable, did not tell the whole story, but unfortunately there was not a simple practical quantitative dynamic adhesion test. We had to rely on the old chisel test, but so much depended on the way the chisel was prepared and the amount of "beef" the man put into it. At the same time the practical value of the chisel test must not be underestimated. He had seen cases in which the tensile test had given higher strength at the bond, whereas the chisel test had shown an extremely brittle condition in the same piece.

As regards cadmium, he suggested it would be most informative if the authors would go farther than they had and link up the influence of cadmium of one, two or three per cent with higher copper contents up to seven per cent.

As Mr. Forrester had asked for information with regard to the effect of bond strength in service, he would say—referring particularly to thin bearings—that bond strength and possibly bond ductility for a given bearing were probably of greater importance than the composition of the white metal. From many hundreds of post-war examinations, he would say that either poor bond or lack of uniformity of the bond was a more prolific cause of bearing failure than any other single cause, apart from the engineering aspect such as fitting. He would rather see a good bond with almost any old composition of tin-base white metal than a poor bond with an extraordinarily fine tin-base composition which might have been the result of prolonged research. He assessed bond strength as of major importance, apart from the engineering aspects of fitting.

With regard to the thermal conductivity of the bond, he imagined that the authors really meant the difference between the conductivity where there was a bond and where there was not a bond, and if there was a gap, however small, between the white metal lining and the shell, the effect of thermal conductivity might be of vital importance. He agreed that that might cause extreme local heating up at the actual bearing surface and subsequent failure, but he would not agree that that was of such importance as the mechanical aspect of the lack of bond.

Mr. Forrester, in reply, said the steel was cold rolled, fully killed steel, and had a carbon content of 0·17 per cent, and no de-wetting. No contraction cracks had been found in the mass of the metal. He agreed as to the practical value of the chisel test and it seemed to be the only test that could be applied to many bearings in practice. As to alloys containing cadmium, the authors chose the ones referred to in the paper because they had been shown to be very interesting from the point of view of high strength bearing metals. However, as Mr. Hollingan had already mentioned this matter to the authors, they had since carried out one or two further tests on cadmium-tin alloys and they would modify their conclusions to this extent, that the lower antimony alloys did not require such slow cooling to obtain maximum bond strength. Cadmium alloys were hot short and if any attempt was made to remove them from the mould below 170 deg. Cent., very low bond strengths were obtained, but if they were allowed to cool down to 100 deg. Cent., without disturbing them, they gave higher values.

The final paper for the day was presented by Dr. R. T. Parker.

EFFECT OF IRON AND SILICON IMPURITIES ON THE TENSILE PROPERTIES AND HEAT-TREATMENT CHARACTERISTICS OF SAND-CAST ALUMINIUM 10 PER CENT MAGNESIUM ALLOY TEST BARS

By R. T. Parker, G. M. L. Cox and A. N. Turner

Summary

It has been observed in the past that, under commercial conditions, sand-cast test bars of aluminium 10 per cent magnesium alloy have variable tensile properties, these variations occurring both within and between groups of bars cast from different melts. In the investigation described in this paper the differences between test bars prepared from the same melts of the alloy were almost eliminated by careful foundry technique, those remaining occurring only with metal of greater impurity content.

To explain the differences between melts, groups of D.T.D. test bars were cast in dry sand from melts containing 0·10–0·75 per cent iron with 0·10–0·50 per cent silicon. It was found that, while an increase of iron has a slightly beneficial effect, an increase of silicon drastically reduces the ultimate tensile strength and elongation. The proof stress value is slightly increased with increasing total impurity content.

The optimum tensile properties of an alloy containing 0·10 per cent iron and 0·10 per cent silicon appear to be approx. 25 tons per square inch ultimate tensile strength and 35 per cent elongation on 2in, these values being obtained from test bars solidified under an air pressure of 100 lb per square inch.

A comparison of low and high-purity aluminium 10 per cent magnesium alloy test bars under varying heat-treatment conditions showed that the high-purity alloy is much the more sensitive to differences in solution time and temperature.

Discussion

Dr. O. R. J. Lee (British Non-Ferrous Metals Research Association) said that in the paper were listed five factors which the

authors suggested might affect the strength of cast welds. The first three were dismissed as being controlled, and standardised by their careful experimental technique. However, he did not think that such a dismissal was justified, and apparently the authors had some doubts on the subject also when they stated that seven bars out of twenty gave anomalous low results which "might result principally from mechanical defects, such as dross inclusions, cold shuts or hot tears, &c." The authors' Observation VII, which indicated that greater scatter was obtained at higher impurity contents, was found, on closer examination, to refer to the experimental results after the "anomalous" values had been deleted, and referred to quite minor variations. It seemed to him that the wide scatter in tensile values must be sought in some minor variations in the casting operations which the authors did not describe in detail, although laying emphasis on the care which they took. Therefore, he would be interested to know full details of the melting and casting operations and, in particular, (1) how the authors assured themselves that their foundry technique eliminated gas porosity and oxide films; (2) why their melting technique for 10 lb of metal occupied a whole day, and what time elapsed, and what else happened between passing chlorine and casting the bars; (3) whether they had assured themselves that no harmful impurity in the flux became transferred to the metal during the apparently long fluxing time, and (4) whether they regarded the lack of oxidation of the metal after removal of the flux as likely to persist during the pouring operations or was any special addition made to the metal with the object of preventing rapid oxidation?

Dr. Parker, replying, said he thought it might reasonably be considered from the practical aspect that they had eliminated gas porosity or at least reduced it to a standard condition by a standard treatment which was used for all melts. They were all treated with chlorine gas for a standard time. As regards the presence of oxide films, the authors had relied on the appearance of batches of test bars and in no case were they able to detect the presence of any discoloration or major discontinuity in any of the fractures. Micro-examination of sections from the test bars also indicated the oxide films were reasonably absent. Shrinkage porosity, although present in varying degrees, according to composition, was also reasonably under control. There was a little tendency for porosity to vary with impurity content but at no time was it greatly excessive. The question of the transfer of harmful impurities from the flux to the melt was a very large one. He appreciated that at the back of Dr. Lee's mind was the question of the presence of harmful impurities such as the alkali metals and whether or not there was a transfer to the melt during the standing time. He confessed that the authors had not covered that question and therefore were unable to say what the effect of such a long standing time was on this transfer, but it was linked up with the effect of heat treatment of the test bars subsequently in an air furnace. However, the fact, as he had already indicated, that no discoloration had been noticed suggested that during heat treatment no reaction had taken place between the atmosphere and the metal.

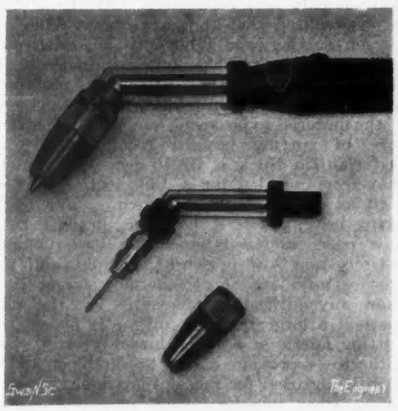
On Wednesday evening a Dinner and Dance was held at the Savoy Hotel.

(To be continued)

Recent Work of the British Oxygen Company, Ltd.

IN the course of a recent visit to the works of the British Oxygen Company, Ltd., at Cricklewood, we were shown several new processes and machines which have been developed by the company during the past year or so.

Two of the new processes of particular interest, and having a wide field of application in industry, were a method of oxy-acetylene flame brazing on commercial aluminium and the "Argonarc" method of welding alloys containing a high percentage of magnesium and certain other metals and alloys.



"ARGONARC" WELDING TORCH

The brazing process has been developed for the joining of pure commercial aluminium or aluminium magnesium alloys with a magnesium content of less than 2 per cent. In normal fusion welding of such items as narrow fillets or close corner joints in light gauge sheet materials of this kind, a high degree of skill is required, in order to avoid the trapping of flux, which will sooner or later cause a breakdown either in the weld or the parent metal. In the flame brazing process 10 to 12 per cent silicon-aluminium filler rods, with a melting point of 585 deg. Cent., are used in conjunction with a specially compounded flux. Standard welding equipment, with the flame carefully adjusted to strictly neutral conditions, is used for brazing. During brazing the flux flows cleanly and rapidly ahead of the filler metal to "wet" and clean both the joint and brazing material. The brazing material spreads quickly and smoothly, forcing the flux ahead of it and at the same time penetrating well into the parent metal to form a strong, clean joint. As commercial aluminium has a melting point of 658 deg. Cent., or 73 deg. higher than that of the filler rod, there is little or no danger of melting away edges or projections formed on the components whilst brazing is in progress.

Not only is this process adaptable for the joining of light gauge sheets, but it has also been used successfully in brazing together metal parts up to ½in thick. We were shown brazed lap and butt joint specimens of various sizes and types which had undergone standard tests, and in every case the point of failure occurred in the parent material and not at the joint.

THE "ARGONARC" PROCESS

In order to overcome the problems associated with the welding of magnesium-rich alloys a considerable amount of development work has been carried out to devise a process which would permit welding without using the type of flux commonly required for gas welding. This work has resulted in the introduction of an inert gas-shielded arc process for the welding of magnesium and aluminium alloys. It can also be used with certain other materials, such as stainless steel, inconel, monel copper and brass. The new process developed by the company is known in this country under the name of "Argonarc" welding, so called because argon is the gas used for shielding the arc. This process employs a metallic arc as the heat source operating in an atmosphere of inert argon gas. The gas fully shrouds the molten metal during welding, and prevents chemical change of any elements in the base metal which would normally combine at fusion temperature with oxygen, hydrogen or nitrogen. The arc is caused to take place between a tungsten electrode and the material to be welded, the electrode being mounted centrally in a nozzle-shaped cup or hood, through which the argon is passed to form a protective envelope round the electrode.

The arc between the electrode and the workpiece provides heat only, and a filler rod, when used, is added separately to the welding zone as with oxy-acetylene welding. The size of tungsten electrode used depends primarily on the current employed, which is related to the thickness of the material to be welded. The rate of electrode consumption is claimed to be exceptionally low, whilst carbon pick is negligible, due to the fact that the only source of carbon available is that present in

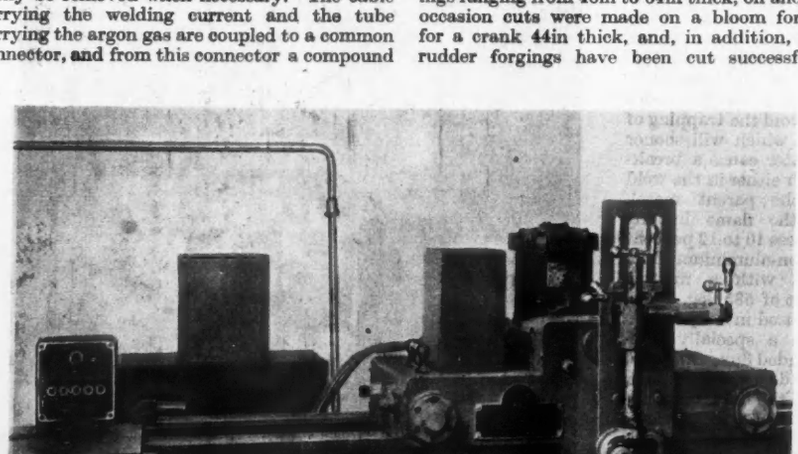
EXPERIMENTAL MACHINE CUTTING 44-IN FORGING

the base metal and/or filler rod, depending upon the type of material to be welded.

As may be seen in one of the photographs we reproduce, the electrode holder used in the "Argonarc" process consists of two parts, the handle or grip to which the compound cable is attached and the head which carries the collet for

CUTTING A STEEL BILLET 48-IN. THICK

holding the tungsten electrode and the argon cup or hood. Two heads which are supplied with each outfit, one for light and the other for heavy work, fit interchangeably into the grip. The collets are screwed into the head and may easily be removed when necessary. The cable carrying the welding current and the tube carrying the argon gas are coupled to a common connector, and from this connector a compound



SHORTER "G. 2" FLAME HARDENING MACHINE WORKING HEAD

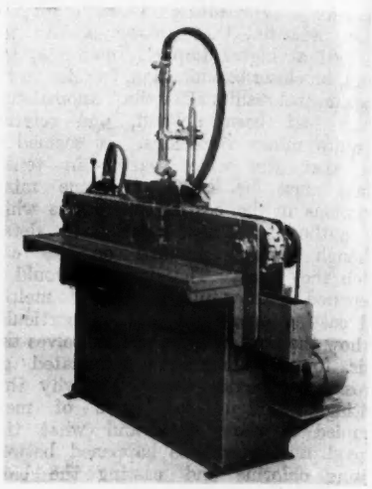
cable and gas tube are in turn connected to the electrode holder.

Although we were informed that a large amount of experimental work still remains to be done on the process, it has already, as we were able to see, developed into a useful and readily available method of welding light alloys. Firstly, the process eliminates the corrosion hazards on welds due to flux residues and, secondly, it minimises the distortion in structures made of sheet metals owing to the highly concentrated, relatively small heat source employed. Both these problems were, in the past, of the greatest importance as far as the welding of magnesium-rich alloys was concerned.

Oxygen Cutting of Very Heavy Steel Sections

For some time the engineers of the company have been investigating the possibility of developing an oxygen cutting machine for the heavy steel industry which would cut the largest sizes of slabs, blooms and forgings both quickly and accurately. At the outset it was realised that the existing principles of oxygen cutting would have to be drastically altered in order to obtain the required results. Hitherto the heating and cutting gas pressures have been increased in relation to the thickness of the material to be cut. Thus, whilst the pressure of cutting oxygen recommended for material 1in thick is 37 lb per square inch, that recommended for a 15in section was as high as 95 lb per square inch. For these extra heavy cutters, however, designs have now been produced which are based on an entirely new low pressure principle, and the nozzles used are of considerably larger bore than any hitherto employed. By the new method a large quantity of gas is fed to the cutting nozzle at a much lower pressure than hitherto—a pressure of only 25–30 lb per square inch being used for metal 48in thick. It was found when experimenting with the normal higher pressures on thick sections that the gases expanded on leaving the nozzle under pressure, with the result that the sides of the cut were uneven, and that full penetration was not achieved. By bringing the gas to the nozzle in large volumes, but at comparatively low pressure it is already partially expanded, and the detrimental effects of swirling, expanding gases in the cut are avoided, and full, even penetration is assured.

A number of tests based upon the new principle have been made during the past eighteen months. In one test cuts were made on forgings ranging from 48in to 84in thick, on another occasion cuts were made on a bloom forging for a crank 44in thick, and, in addition, 44in rudder forgings have been cut successfully. As a result of these tests extra heavy cutters have now been developed in three sizes for cutting steel 12in to 48in, 49in to 84in, and 84in thick and over. The smallest of these cutters can be fitted to the firm's standard 55in universal cutting machine, but for the other two sizes special machines are designed to specific needs. For instance, where the cutter is to be employed cutting hexagonal ingots, a special machine designed to rise and fall over the contours of the ingot will be required, and, similarly, a special machine will be required to deal with forgings of various shapes. An experimental machine cutting a 44in diameter forging is illustrated in another of the photographs we reproduce. These extra heavy cutters are designed for attachment to the firm's profile cutting machines,



SMALL FLAME HARDENING MACHINE

and in one of the engravings on this page is shown a 55in machine profile cutting a 48in thick steel billet.

A Hot Cropping Machine

We were also shown the prototype of a machine which has been designed for the purpose of hot cropping blooms or billets in rolling mills. This machine is of simple design. It consists of an oxy-acetylene cutting head fitted on the nose of a carriage which traverses it across the width of a billet, coming off the rolls at a temperature between 900 and 1100 deg. Fah.

The cutter is designed to cut blooms or billets of any thickness at a speed of not less than 18 seconds per cut and works on the new low pressure, large volume of oxygen principle described above. The machine is fully automatic in operation, the setting of the cutting head in relation to the thickness of the billet to be cut being rapidly and easily effected by means of push buttons on a remote control panel. At the end of the cutting stroke the head and carriage are automatically retracted into a substantial enclosed protective chamber built on one side of the rolls.

The design of the machine is such that its use involves only small maintenance costs and in the event of a breakdown a reserve carriage or head can be installed on the track in a matter of minutes. Its weight and size are such that it can be fitted to any existing rolls with little or no necessity for structural alterations or special foundation work.

Shorter Flame Hardening Machine

A new fully automatic Shorter "G.2" hardening machine for gear teeth, &c., incorporates a number of interesting features. As can be seen in the photograph reproduced herewith the blowpipe assembly is adjustably mounted on the front of the machine head, which is carried on four wheels running in guideways machined in the table of the cross carriage. This cross carriage is in turn supported on rails running the length of the quenching water tank, in which the work being treated is suspended.

A geared electric motor which, through a clutch drive, traverses the head over the table works in conjunction with a Ward Leonard set designed to give the table an infinitely

variable range of traversing speeds. Traversing speed is simply set by the turning of a knob, and an auxiliary control switch enables the head to be stopped and restarted at any predetermined speed without alteration of the main control knob. The main driving clutch is designed to permit the instantaneous stopping and restarting of the machine head. At the end of each hardening operation the motor is de-clutched and the counterbalanced head is withdrawn by hand ready for the next operation. An auxiliary clutch mechanism incorporated in the head drives a secondary shaft, which can be used as a separate drive to the work-mandrel in the tank for the treatment of drums, rollers, worm wheels, &c.

The front plate of the machine head extends downwards in the form of a slotted apron, on to which a rigid guide finger can be bolted when helical or spiral gears are being treated. This finger meshing with the wheel brings the teeth progressively into proper relationship with the burners.

Four tee slots are cut along the full length of the table along which the machine head is driven. A series of dogs can be set in the slots at appropriate positions to contact plungers extending downwards from a control box at the rear of the head. These plungers are actuated in sequence by the dogs as the head moves along the table. As the plungers are depressed by the dogs the gas, quenching and cooling jets are switched on in their predetermined order and cut out at the end of the traversing or working stroke of the head.

At the conclusion of each working traverse, as the head is withdrawn, a thruster operated ratchet and pawl indexing mechanism automatically indexes the workpiece to bring the next section into position. A mechanically operated counter working in conjunction with the indexing mechanism records the number of teeth treated and automatically shuts down the machine when the pre-set number of teeth has been reached. The control equipment, including push buttons, relays, contactors, timing clock and counter, are mounted together on a single panel housed in a separate cabinet.

A Small Parts Hardening Machine

Another new Shorter machine is also illustrated. This machine has been designed for the continuous hardening of small areas on components such as tappet heads, push rod ends, &c.

The machine consists of a substantial fabricated base along the top of which runs a steel link conveyor, 4ft 6in long, driven by a small variable speed electric motor. Each link of the conveyor carries a specially designed jig for holding the article to be hardened. A pillar fixed rigidly to the back of the machine, midway along the conveyor length, carries an adjustable bracket supporting a water-cooled blowpipe and the quenching water nozzles. Water-cooled plates on each side of the conveyor support and guide it as it passes through the flame hardening area.

In operation the speed of the conveyor is arranged according to the heating time required for the components being treated. The machine runs continuously, the components being loaded in to the jigs at one end and being unloaded after treatment at the other. The jigs can be so designed that the components drop out of them into a tray at the unloading end as the conveyor starts on its return track. This return track carries the conveyor through the quenching water tank to cool the jigs and chain between each working cycle.

Argentine Iron Mines and Blast-Furnace*

THE importance of Argentina as a consumer of iron and its derivatives was accentuated during the immediate pre-war period as a result of rapidly expanding industrialisation. The nation was almost completely dependent upon imported supplies, and therefore suffered an intense crisis as a result of the widespread effects of the recent war.

The situation compelled the State to reduce its dependence upon outside sources of supply as soon as possible. There were many difficult problems to be solved, since it was hoped to work our own iron ore deposits, the only ones upon which we could depend in an emergency. Until recently, known deposits provided scanty reserves, and were badly sited for economic development.

Intensive surveying revealed the existence of the Zapla deposit, the estimated reserves, location and high ore content of which justified development. Great technical handicaps had to be surmounted when building up this new venture, because the country lacked the necessary experience and had no facilities for making the plant and machinery of proved efficiency, so necessary to a modern installation of this type. Theoretical knowledge of the technical problems to be solved was not enough for large-scale development. It was therefore decided to call in the help of a Swedish firm, which contribut d efficiently to the initial development of the organisation.

The world war made it impossible to import plant and equipment which would provide a guarantee of high-class performance. Notwithstanding, the need was so great that all available plant and materials in the country were used to the utmost extent. Having thereby solved the problem of shortage in the best manner possible under the circumstances, the first pig of Argentine cast iron was produced on October 11, 1945.

Installation and Operation of Blast-Furnace

Plant at Palpala comprises the blast-furnace; equipment for transporting ore, limestone and charcoal; turbo-blowers; preheaters for air supply to the blast-furnace; plant for purifying and leading off the blast-furnace gas; sintering plant; and stock yards for raw materials, &c. There is also an electric power station with boilers fired by blast-furnace gas, stores for consumable materials and workshops for general repairs.

Blast-Furnace

The blast-furnace was designed and constructed to operate on wood charcoal, the latter being available locally in abundance. Although it is certain that this fuel will limit the output capacity of the blast-furnace to well below that common with a furnace using coke as a fuel, on the other hand it results in the production of a higher quality cast iron.

The refractory lining is able to withstand the heaviest service and is of high quality, produced entirely in the country. With the object of not overloading the lower part of the structure, it is supported by twelve columns which transmit the weight to the foundation; at the same time, free expansion of the lower part is permitted. The closing bell and loading hopper of a Parry system surmount the furnace, the raw materials being delivered to a loading platform. Local materials were used for all the structural work.

Transport

The iron ore is transported from the mine to the stock piles at the treatment plant by means of a bicable continuous ropeway built by a contractor. Below the stock piles is a tunnel in which belt conveyors are installed for raising crushed ore to a classifying plant where it is graded into different sizes by vibrating screens. Limestone and manganese, which also pass through jaw crushers, are taken from their respective stock piles. The classified raw materials are stored in silos, whence they are conveyed to the loading platform by means of an automatic bascule tipping wagon. Charcoal is unloaded from railway wagons by a mobile belt conveyor and stored in a covered shed. It is conveyed to the loading platform by means of an aerial cableway.

Turbo-Blowers

Air is supplied to the furnace by two turbo-blower units, each with a capacity of 200 cubic metres per minute, raising atmospheric pressure by 0·5 kg per square centimetre. The complete installation comprises six separate turbo-blower units driven by electric motors, absorbing 400 h.p. with four blowers in action, the other two units being held in reserve. The equipment was supplied and erected by Fischbach and Enquin, engineers, of Buenos Aires.

Air Heaters

The air to the blast-furnace is preheated in order to economise fuel. A Tholander type of heater is used in this case, made in the country, which heats the air to 450 deg. Cent. In due course a Lindblom heater will be installed, and the air temperature can then be increased to about 600 deg. Cent. This preheated air will be passed into the furnace through water-cooled tuyéres.

Gas Purifiers

The rising column of gas is led off from the upper part of the furnace through pipes to a cyclone primary purifier, where the heaviest dust is deposited, derived from the ore, limestone and charcoal. In series with this primary purifier two secondary cyclones operate in parallel, completing purification. The purified gas is used as fuel in the boilers and in the air preheater. All the equipment was made locally from material supplied by the Military Steelworks.

Sintering Plant

The crushed ore must be sintered and for this operation it is lifted by an elevator to the hoppers of the sintering plant. Similarly, the small charcoal, after being sieved in the stock-yard, is taken in narrow-gauge wagons to provide the fuel for sintering. From the hoppers the material falls on rotary unloading platforms with adjustable scrapers, whereby a convenient mixture is obtained. From there the mixture is raised to the loading hopper of the sintering furnaces. Later, by a process of grinding and sievings the sintering furnaces are loaded with the material to be treated, over which a thin layer of fine charcoal is spread to provide the means of ignition. Oil is spread over the charcoal to start the fire and the gases are led off to a chimney through exhaust ducts. When sintering has been completed, the sintering furnace is lifted by a crane and transported to a tipper which discharges the material into a crusher for reduction to the required size. The sintered material is then lifted by crane into the storage silo and transported to the blast-furnace in a tipping wagon.

Electric Power Station

Steam is supplied by two water-tube boilers operating at a pressure of 15 kg per square centimetre, and a steam temperature of 300 deg. Cent. A reserve oil engine generating plant of 450 kW capacity is also provided, giving a 50-cycle, three-phase a.c. supply at a potential of between 220 and 380 volts.

Operation of Plant

The consumption of raw material per ton of iron produced is approximately:—Charcoal, 1000 kg to 1100 kg; limestone, 400 kg to 500 kg; ore with 47 per cent iron, 2000 kg.

These quantities represent average values, consumption of charcoal and limestone being related to the type of cast iron which it is desired to produce. For example, if the cast iron is to be rich in silica and manganese, it is necessary to increase the proportion of charcoal and to reduce that of limestone. On the other

* Abridged translation by Rolt Hammond, A.C.G.I., A.M. Inst. C.E., of a report on the iron mines and blast furnaces of the General Directorate of Military Factories, Argentina. Prepared by the General Directorate of Military Factories in the Argentine Republic.

hand, if it is desired to increase the output of the furnace without insisting upon a definite type of cast iron, the consumption of charcoal can be considerably reduced.

It is interesting to note the influence of air preheating, within certain limits, on the consumption of charcoal. In effect, for each type of cast iron there is an optimum air temperature. If this temperature is exceeded, the fire rises in the furnace and the height of the zone in which indirect reduction takes place is diminished, output capacity decreasing with resulting increased consumption of charcoal. If the air enters the furnace at the optimum temperature the consumption of charcoal is at a minimum.

Output is appreciably influenced by the degree of crushing of the raw materials making up the charge. Excess of dust, particularly that from charcoal, causes irregular operation leading to explosions and even to complete shutting down of the furnace. Careful screening is therefore necessary to eliminate dust and particles of small size. The latter are produced in the sintering plant.

Particular care should be devoted to the materials before they are loaded into the furnace, because irregular loading may lead to unequal distribution of the rising column of gas. The furnace is tapped every six hours, the molten iron being led to a gyratory feeder which pours it into either sand or cast iron moulds. The slag is continuously removed and granulated in water or recovered in moulds, where it gradually cools and acquires a compact structure.

After six months' operation it was possible to reduce labour costs to that of similar plants elsewhere. Productive labour amounts to 12 man-hours per ton of cast iron, and this figure will be further reduced with increased experience.

The extent of the ore body, as well as its high iron content, should ensure that an abundant supply of good raw material is available for the plant for many years to come. The wood charcoal has given excellent physical and chemical results. The production of a blast-furnace depends upon its volume, or, in other words, upon the quantity of fuel introduced into it. The greater the density of the fuel, the greater will be the production of the furnace. In this case the charcoal has a high density, about double that found in other countries, which is a great advantage.

The maximum capacity of a furnace depends, amongst other things, upon the mechanical resistance to compression of the fuel used. Our charcoal, derived from hardwood, has a high mechanical resistance, and this is also a great advantage.

Plans for the immediate future envisage the construction of nine blast-furnaces, thereby increasing production considerably. This output, both as to its quality and its cost, will be entirely absorbed by the national metallurgical industry.

Testing a Transmission Line Tower

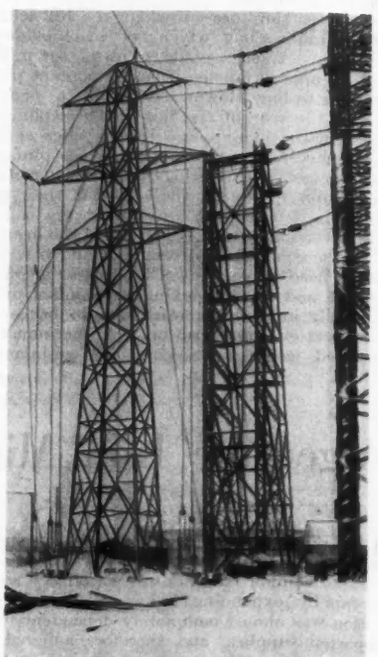
THERE is little novelty in the mechanical testing of transmission line towers, and for a number of years it has been a common practice to subject new designs of towers to tests which simulate the normal and abnormal mechanical loads that are expected to arise under service conditions. The tests that were recently carried out on a prototype 132-kV double-circuit tower for the North of Scotland Hydro-Electric Scheme were, however, of more than usual interest because of the exceptionally severe weather conditions that prevailed at the time.

The tower that was tested is known as a type D. 2°, which is used in straight line positions and for small line deviations up to 2 deg. Towers of this class satisfy the requirements for about 80 per cent of an average transmission line, angle and section towers being used on the remaining positions. The D. 2° tower is designed for use with suspension insulators supporting six steel-cored aluminium conductors (7/0·11in steel+30/0·11in aluminium) with a single earth wire (7/0·11in steel + 12/0·11in aluminium) and an average span of 900ft. The overall height of the D. 2° tower, built up of mild steel angle sections, is 86ft the total weight of the structure above ground being about 3½ tons.

Briefly, the Hydro-Electric Board's specification for transmission lines stipulates a factor of safety of 2½ for "normal" transverse and vertical loading with all wires intact, with a factor of safety of 1½ for broken wire conditions, which impose an additional longitudinal load on the tower. The applied test loads are the working loads multiplied by these factors of safety, so that under full test conditions the tower is strained to the elastic limit of tension members and the crippling value of struts, with a small margin to allow the test loads to be held without any permanent distortion of the tower members.

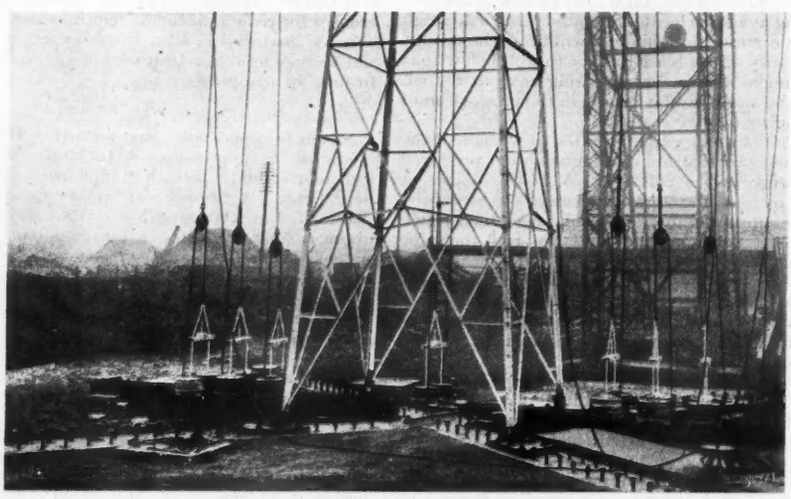
The tests on the Board's prototype tower were carried out in Hereford at the test plant of Painter Brothers, Ltd. This plant provides complete facilities for mechanical tests on towers up to 100ft high, with the possibility of accommodating larger towers should the demand arise. Artificial loads can be applied to the tower to simulate the loading conditions that may occur in practice. A horizontal load applied transversely to the axis of the line represents the effect of wind pressure on the ice-loaded conductors and on the tower superstructure. A horizontal load applied in the direction of the line reproduces the conditions corresponding to one or more broken conductors. Both of these loads are applied at a convenient point near the top of the tower by electrically driven winches through oil-pressure dynamometers connected to dials in a central control room. At the same time vertical loads, corresponding to the dead weight of ice-loaded conductors in a span, are applied through the medium of suitable weights.

The illustration below shows the tower and part of the test plant after the final tests had been successfully applied. In the background can be seen one of the anchor structures from which the longitudinal load is applied. A second anchor structure, which appears in silhouette on the extreme right of the engraving, provides the means for applying the transverse load; the winch cables and dynamometers can be clearly discerned. The plant includes a third anchor structure which, like the first, is used for reproducing broken conductor conditions, and our illustration shows the appropriate test tackle in position on the end of the middle cross arm of the tower. The second engraving from an earlier photograph is reproduced here to show the test bed to which the tower is secured during the test, and to indicate the application of the dead load. The cast iron weights rest on double channel section bearers which are supported at their ends only. The elastic deflection of these bearers acts as a shock absorber, so that, when the winch is operated to raise the weights, the vertical load on the tower is applied without shock.



PROTOTYPE TOWER RIGGED FOR TESTS

After a month's postponement, due to the recent bad weather, when temperatures were too low to operate the plant, the test was arranged to be carried out on March 5th. A snow blizzard raged throughout the day but in spite of the adverse weather conditions, it was found that the plant, including the oil system, was working satisfactorily, and it was decided to proceed with the tests. Under the prevailing conditions the task of climbing the tower and changing the tackle and dynamometers after each test was no sinecure, and it says much for the ability and enthusiasm of the erection gang that the tests were completed without mishap. Subject to the receipt of steel in adequate quantities, the bulk fabrication of these towers can now proceed at the Glasgow works of William Bain and Co., Ltd., who made the prototype to the designs of Blaw Knox Ltd., Clifton House, Euston, London.



ARRANGEMENTS FOR APPLYING DEAD LOAD

Zürich Sports Stadium

IN Zürich, the biggest city in Switzerland, with a population of 250,000, there was recently completed a covered sports stadium, the design of which shows features of considerable interest. A photograph of the interior and drawings of the structural steelwork are reproduced herewith. The stadium is primarily intended to serve as a velodrome (cycle race track), with seating capacity for 11,000 spectators. Because of the climate of Zürich, with a record of rainfall during more than 150 days a year, the municipality decided to build a covered stadium, so as to permit sporting events to be held in all weathers.

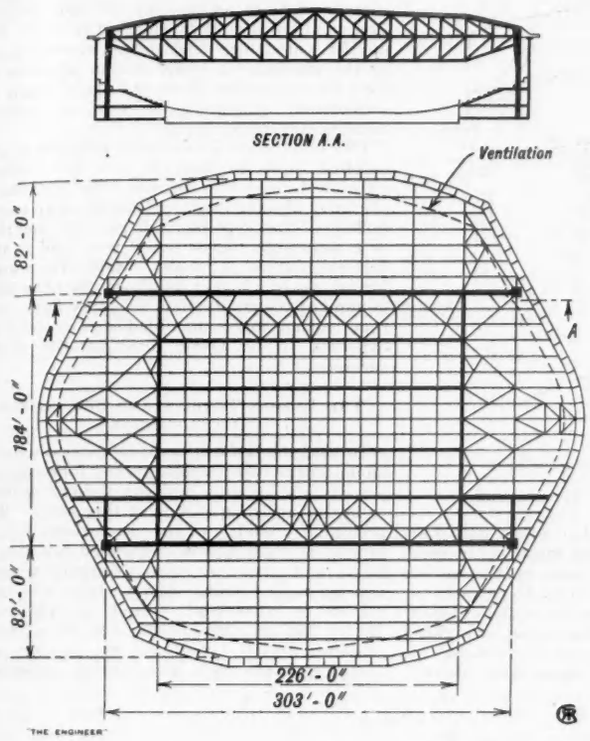
Claimed to be the largest of its kind in Continental Europe, the stadium has a volume of more than 5,000,000 cubic feet, and a floor area of 107,500 square feet. Its internal space is obstructed by only four interior supports, placed near the exterior wall, and the unobstructed area comprises more than 100,000 square feet, roofed over without intermediate supports. In plan the shape is approximately that of an ellipse, with major and minor axes of 395ft and 347ft respectively.

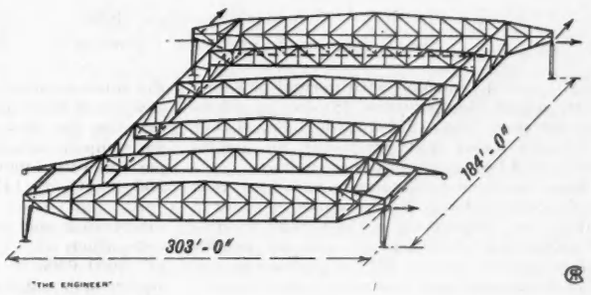
The floors and grand stands are in reinforced concrete, and the track is of wooden construction. The structure is covered by a roof, which has a very slight pitch, and is constructed of lightweight concrete resting on wooden rafters and battens. From the roof is suspended a ceiling of asbestos cement sheets, attached to a wooden framework. A space 19ft deep between the roof and the ceiling encloses all the steelwork, excepting the lower parts of the four main trusses, thus hiding from the spectators' view an unsightly part of the structure.

As is indicated in the accompanying drawings, the four main supports are placed at the corners of a rectangle measuring 184ft by 303ft. Inside this rectangle the structure comprises two main trusses, of 303ft span and with a depth of 32ft 10in, each supported on two columns; two connecting trusses, of 184ft span and 32ft 10in depth, supported by the main trusses; four longitudinal trusses of 226ft span and 16ft depth; twenty-five lines of secondary beams; wind bracing beams; and purlins supporting the roof. Outside the 184ft by 303ft rectangle, the framework consists of a system of trusses with spans not exceeding 82ft, resting at one end on the main trusses and at the other on the exterior walls, where flexible connections give 2 deg. of freedom. The four supporting columns rest on cast steel bases, fastened by circular bearing plates, 3ft 3in in diameter, to reinforced concrete posts.

Each portal frame, consisting of a main truss and its two supports, forms an isostatic system, for which a supplementary degree of freedom is obtained by a hinge at the junction of the columns with the main truss, the two other degrees of freedom being provided by hinged bases at the foot of each column. Thus two isostatic frames are created in which vertical loads do not produce any horizontal thrust.

The main trusses were erected from high-tensile steel, St. 44, of which the ultimate strength is 44 kg per square millimetre, or 62,500 lb per square inch. For the other frame members ordinary mild steel, St. 37, was chosen. The contract, involving 670 tons of steelwork, was awarded to Messrs. Eisenbaugesellschaft, who also prepared the engineering calculations. Mr. K. Egender was the architect.





CONSTRUCTION OF STEEL ROOF FRAMING

ZÜRICH SPORTS STADIUM

SELF-CONTAINED X-RAY CENTRE AT LEYLAND.—One of the more interesting additions to production and research equipment installed at Leyland Motors, Ltd., is a self-contained X-ray centre for the testing of ferrous and non-ferrous castings produced in the company's foundries. The main advantage of the use of X-rays in engineering is that it provides a non-destructive method of examining castings, &c. If necessary, every single casting can be examined without damage, whereas previously inspection entailed cutting, sectioning and destroying the casting, thus limiting examination to specimens only. In addition to the equipment in operation at the company's Leeds foundry for non-ferrous castings, two X-ray sets are now housed at the recently built centre at Farington. The equipment includes two X-ray units. A Philips 100-kV set, with a range of 30 kV to 100 kV, which can be selected in ten stages, is used for the examination of aluminium castings, and a Siemens set, capable of operating up to 220 kV, for use with iron and steel castings. The centre also includes a fully equipped white-tiled photographic room, with modern developing and washing apparatus. With low-powered tubes, which produce long electromagnetic waves, it is often possible to make use of visual examination, using a screen which fluoresces as a result of the action of the X-rays. If a casting is inserted behind the screen in the path of the rays a shadowgraph can be seen by an observer situated on the opposite side of the screen. Usually, however, the X-ray is used with photographic film, which is placed in a cassette behind the casting. The rays, after passing through the casting, act on the silver salts of the film, producing a latent image which can be developed and fixed in the same way as in an ordinary photograph.

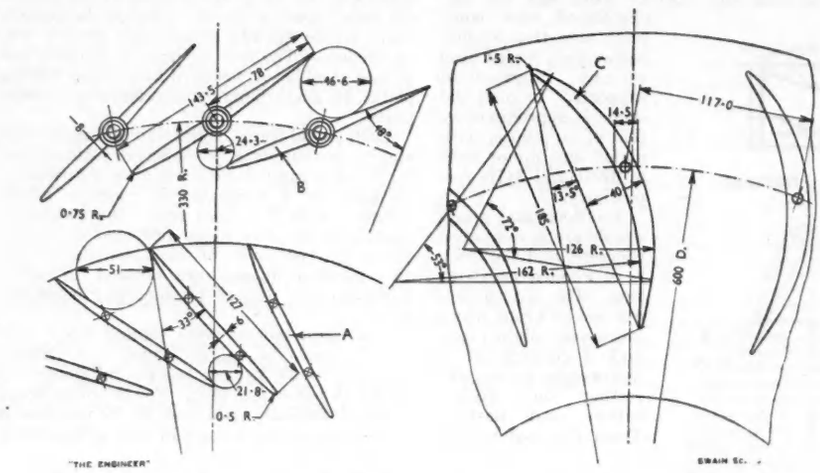
A Contribution to the Solution of the Gas Turbine Problem*

By A. J. R. LYSHOLM, M.I. Mech. E.†

The First Stage

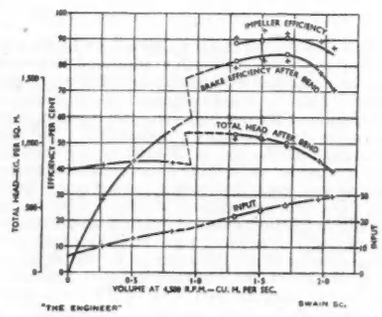
Early gas turbine inventors and experts (*e.g.*, Parsons in his first turbine patents of 1884 and Stolze in 1900) thought that a gas turbine should incorporate a normal single or multiple-stage "steam" turbine with normal or somewhat higher temperature (Stolze mentions 300-400 deg. Cent. (572–752 deg. Fah.)), but they soon found that practically no surplus work could be expected by these means.

Later on, the most favoured opinion was that single-stage turbines should be used in order to reduce the temperature of the turbine blading by expansion of the gas as much as possible before the gas stream hit the turbine blades. Thereby a considerable increase in gas temperatures appeared possible, and the end expansion or "end" temperature became the most important factor in gas turbine calculations. The result of adopting single-stage turbines was that high peripheral speeds had to be used, and thus high stresses in turbine blades and discs were unavoidable. Furthermore, a high thermodynamic efficiency could not be expected, and in most calculations a figure of 70 per cent was employed. In this way Baumann in 1905 and 1906 arrived at a thermal efficiency of 5 per cent without, and 15 per cent with, a regenerator. Stodola (1922) wrote that even by increasing the "end" temperature to 1000 deg. Cent. (1832 deg. Fah.) the expected thermal efficiency could not exceed 24 per cent.



A, impeller blades. B, adjustable diffuser blades. C, fixed diffuser blades.

Fig. 1—*Diagrams of Impeller and Diffusers of Bofors Test Turbine*



+ Original tests November-December, 1931.
O Adjusted diffuser vanes, March, 1932.

Fig. 2—*Compressor Tests*

In the late 1920's it was generally believed that the gas turbine was a Utopian scheme until the metallurgists could develop a material suitable for withstanding high stresses at extreme temperatures. However, this has, to a certain extent, been fulfilled already.

The author's idea in attacking the gas turbine problem was the opposite; namely, to take available materials and to use a multiple-stage turbine with the highest attainable thermodynamic efficiency and low peripheral speeds at the inlet in order to get low blade and disc stresses in these parts. That meant, of course, exposing the first turbine stage to the initial gas temperature, which in order to get a competitive prime mover had to be in the order of 800 deg. Cent. (1472 deg. Fah.) abs. or higher.

At that time commercial materials, of martensitic and austenitic type, were obtainable which at a stress of 4000–6000 lb per square inch could withstand temperatures of 800 deg. Cent. (1472 deg. Fah.) abs. and 950 deg. Cent. (1742 deg. Fah.) abs. respectively. That is to say, the total creep did not exceed 1 per cent in 100,000 hours—a figure which was used in steam turbine practice.

The preliminary calculations, which were made in 1929–30 and were based upon the premises given above, gave astonishing results. The author's first gas turbine patents were filed in March, 1930.

To get the desired high turbine efficiency it was considered that the turbine should have the following :—

(1) A full admission reaction blading.

(2) No control valves. (For a back-pressure steam turbine the control valve reduces the thermodynamic efficiency by about 2 per cent.)

(3) A high Parsons figure, $\Sigma u^2/\Delta i \geq 2800$, where u is the mean peripheral speed of the blades in metres per second, and Δi the adiabatic heat drop in kilo-calories.

(4) Blades which are long in comparison with their diameter, in order to reduce leakage. (This condition also resulted in a high aspect ratio, reducing the end losses of the blades. As inlet volumes in gas turbines generally are very large, this condition was comparatively easy to fulfil.)

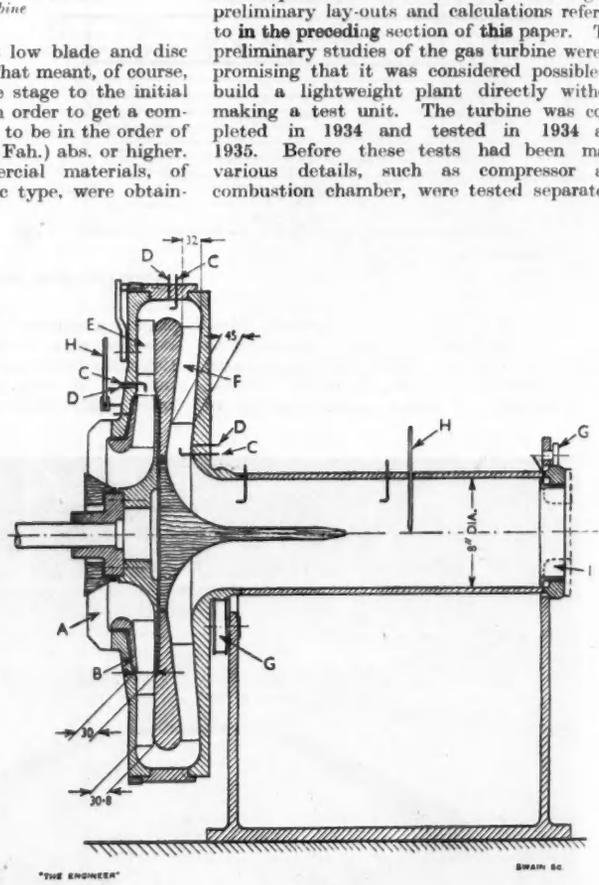
(5) A large exhaust area to reduce leaving and carry-over losses. (Owing to the temperature drop in the turbine the exhaust parts are cooler, and for that reason it was easier to fulfil this condition than to cope with the high inlet temperature.)

The turbine structure, therefore, should have a small inlet radius to ensure low stresses, and a comparatively large outlet radius in order to get the large exhaust area and reduce the large number of stages required by the high Parsons figure and low peripheral speed at the inlet. In the U.S. patent specification this was expressed by the wording "a blade system providing a path for expansion of motive fluid having a substantial component for flow in radially outward direction."

The most suitable turbine structure which satisfied these requirements was the double-rotation Ljungström turbine, the maximum efficiency obtained with a back-pressure steam turbine of that type being 88 per cent, and this or a somewhat higher figure was used in the first calculations (Lysholm, 1930). The reason for the use of a higher figure was that the inlet volume of the gas turbine was very large, and thus leakage losses and blade losses could be expected to be lower than for the steam turbines.

The Bofors Turbine and Subsequent Developments

In 1932 the Bofors Company decided to build an aeroplane test turbine, mainly following the preliminary lay-outs and calculations referred to in the preceding section of this paper. The preliminary studies of the gas turbine were so promising that it was considered possible to build a lightweight plant directly without making a test unit. The turbine was completed in 1934 and tested in 1934 and 1935. Before these tests had been made various details, such as compressor and combustion chamber, were tested separately.



A Straight inlet vanes. D Static head. G Supporting rollers.
B Impeller. E Adjustable diffuser blades. H Thermometer.
C Total head probe. F Fixed diffuser blades. I Orifice.

Fig. 3—*Test Rig of Centrifugal Test Compressors*

The test impeller was made with twenty-four backwards-curved blades, the outlet blade angle being about 57 deg. The diffuser was made in two parts as follows :—

(1) Thirty-six radial-flow, practically straight, streamlined blades, which could be adjusted

* Abstract. Institution of Mechanical Engineers, March 14th, 1947.

† Consulting engineer and chief engineer, A. B. Ljungströms Angturbin, 1928–44.

by means of links similar to those of water turbine guide blades. This mechanism was not sufficiently accurate, and in later tests each diffuser blade was adjusted by hand, which increased the efficiency slightly.

(2) Sixteen curved diffuser blades in the ingoing passage.

Fig. 1 shows diagrammatically the impeller and diffusers. All tests were made at about 4450 r.p.m., and corrected to 4500 r.p.m., which corresponds to a peripheral speed of 385ft per second, the proposed maximum peripheral speed in the gas turbine being 650ft per second. The maximum efficiency obtained was 84 per cent, as measured by total head after the outlet

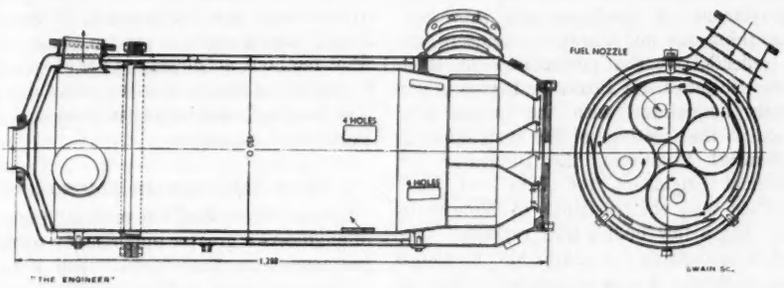


FIG. 4—*Bofors Combustion Chamber*

bend and the stator reaction, but the temperature efficiency, corrected for radiation and dynamic recovery, was as a rule somewhat lower. The maximum impeller efficiency was 91 per cent. For a radial-vane impeller the corresponding figures were 77 per cent and 85 per cent respectively (see Fig. 2).

Fig. 3 shows the test rig. Power was supplied from a steam turbine and the reaction of the stator measured by means of a scale.

The combustion chamber is shown in Fig. 4. It had an outer air-cooled casing and a liner which restricted the amount of air to the ignition and primary combustion zones. The four burners were of the air-swirl type, and the injection nozzles of the constant-pressure tangential-entry atomisation type. The injection pressure was about 1400 lb per square inch.

rotor was driving the seven-stage high-pressure compressor. The maximum design speed of the turbine was 8000 r.p.m.

The gas turbine was started by means of a de Laval type steam turbine driving the high-pressure compressor, and the low-pressure compressor was started automatically by the air sucked through the compressor and expanding through the turbine. No troubles were experienced with the turbine blade rings and the heat elastic design (comprising radial pins, carrying blade rings, outer turbine discs and "steam" chests). The only permanent set was noticed in the largest diameter blade ring, which was milled out of a solid ring of chromium-molybdenum steel, corresponding to the "Durehete" specification. The inner rings were welded of an austenitic nickel-chromium steel to the Krupp specification WF.100.

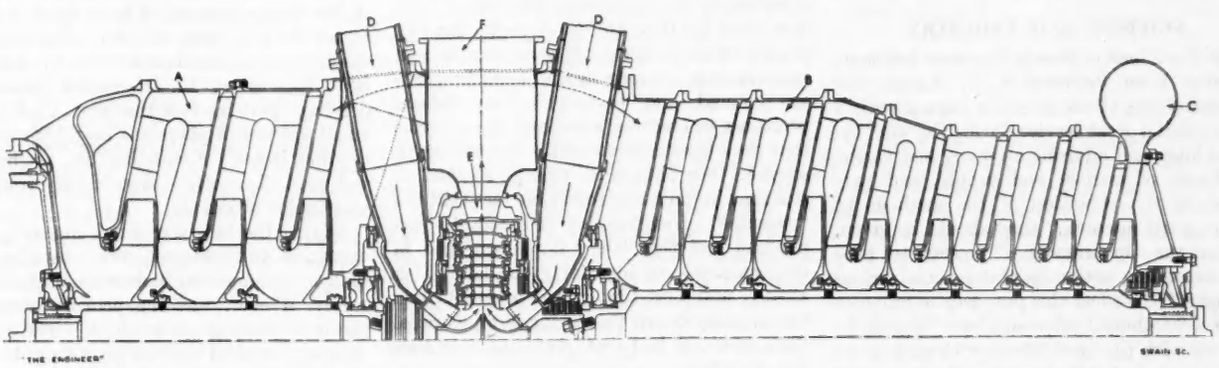
The greatest mechanical troubles were caused by the dummy pistons, the outer parts of which seized several times in spite of the fact that they were cooled in air of about 300 deg. Cent. (570 deg. Fah.) temperature. At first these parts were turned out of solid discs of "Durehete" similar to the glands of a Ljungström turbine, but this material was found to be entirely unsuitable because it readily burns in air when the seals start to rub. Sealing strips of austenitic "18–8" steel were then fitted, but seizing still occurred occasionally. These troubles were probably due to the lightweight construction, which caused warping of the outer turbine casing as well as the dummy pistons themselves.

Another serious trouble was the pumping of the compressors, which prevented a proper testing of the unit. It was necessary to take away the first compressor stage and run the remaining three stages on that side with a lower speed than that of the high-pressure end. However, the turbine was run up to a maximum temperature of over 700 deg. Cent. (1290 deg. Fah.) and measurements of fuel consumption and the output indicated an efficiency of about 15 per cent at 600 deg. Cent. (1110 deg. Fah.) and 70 lb pressure.

In the meantime the idea of a rotary screw compressor was conceived, and this was tested at the end of 1935. The tests were very promising and indicated that a better and smaller compressor could be built than the eleven-stage centrifugal compressor used for the Bofors turbine. It was also of the positive displacement type, which could not pump. A paper on this compressor was read by the author in 1943‡ and for further information reference should be made to two papers published in the U.S.A.§

At the end of 1935 it was decided to abandon further testing of the Bofors turbine and an experimental 2000-kW plant was proposed. The intention was to complete the high-pressure turbine and compressor first, test them separately and then build the complete plant—a far more modest programme than that of constructing an aeroplane turbine. This scheme was, however, never realised. All compressors were of the Lysholm type, and the turbines of the conical-flow reaction type. To allow complete freedom of running the plant at any desired temperature all compressors and turbines were coupled on the same shaft, and thus good efficiency could only be expected at full load.

(To be continued)



A Low-pressure compressor. B High-pressure compressor. C Outlet scroll. D Inlet pipes. E Turbine. F Outlet.

FIG. 5—*Section Through Bofors Turbine*

The fuel pump consisted of two pistons operating against a spring-loaded accumulator. The maximum heat release was 1,250,000 B.Th.U. per cubic foot per hour at a pressure of 1·7 atmospheres, and the throttling loss in the chamber was 0·54 B.Th.U. per pound.

The inlet pipes to the turbine were all jacketed and cooled by means of a stream of compressed air. This jacket was extended to the turbine blading forming an enveloping air shield, and thus all parts except the blade rings were not subjected to a higher temperature than about 300 deg. Cent. (570 deg. Fah.).

A section through the turbine is shown in Fig. 5. The low-pressure compressor, consisting of four stages, was driven by one rotor of the double-rotation Ljungström turbine, which also delivered useful power. The other turbine

Proposed Humber Bridge

A DEPUTATION from the Hull Corporation and the Lindsey County Council, together with the Members of Parliament for the areas, met Mr. G. R. Strauss, M.P., Parliamentary Secretary to the Ministry of Transport, recently. The deputation was introduced by Commander Gurney Braithwaite, M.P. The Minister of Transport was urged to agree in principle to the bridging of the River Humber by means of a single-span suspension bridge, and it was sought to persuade him to accept the bridge as part of the trunk road system of the country, and therefore a project which would be carried out at the cost of the Exchequer. A full discussion ensued, as a result of which Mr. Strauss made it clear that, desirable as the scheme for the bridging of the Humber estuary was, his Ministry could not, having regard to the present economic situation of the country and other commitments, authorise the project to proceed at the present time. The deputation emphasised that it fully realised the present position and was not pressing for the immediate building of the bridge. Mr. Strauss explained that the Government's plans for trunk road development, which had been presented to the House of Commons, did not include a crossing of the Humber at Hull, and therefore he was not in a position, on the evidence before him, to agree that this scheme should rank as a trunk road project. It was explained to the Parliamentary Secretary that a great deal of scientific and engineering investigation would be necessary in a project of this kind before the design of the bridge could be finally settled. Furthermore, the deputation urged agreement to this preliminary work being put in hand as soon as possible.

‡ "Proc.," I. Mech. E., 1943, Vol. 150, page 11, "A New Rotary Compressor."

§ Lysholm, A. J. R., Smith, R. B., and Wilson, W. A., 1943 S.A.E. *Journal*, Vol. 51, page 193, "The Elliott-Lysholm Supercharger."

THE ENGINEER

MARCH 21, 1947

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NOTICE TO READERS

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SCIENCE AND INDUSTRY

IN *The Times* of March 13th may be found a letter from Professor J. D. Bernal, the general theme of which is that since scientists performed a great service during the war "in examining and advising on many and varied problems of warfare and supply, and particularly the evolution of the methods of operational research," they should be given, under the Government, "powers to take corresponding action in this no less serious danger." To effect this purpose, he proposes that a "technical sub-committee" should be set up with the new Advisory Council as its nucleus and should be given the necessary "directive" and "powers." Whilst we welcome this support of our desire to see the duties of the new Council clearly defined, we venture to think that Professor Bernal does less than justice to the industries of this country by his implication that a heterogeneous council of "scientists," without special and intimate knowledge of the industries, could promptly set them to rights and so increase "the admittedly low efficiency of our productive industry."

The crux of this matter is perhaps the definition of "scientists." It would be useful to have Professor Bernal's interpretation of that difficult word. Does he mean an exclusive body of persons whose life is devoted to research and inquiry into the inner mysteries of things, or will he agree that since science is a mode of thought, everyone who applies logical and informed thinking to the solution of such problems as may come before him is a "scientist"? If he accepts the latter, and now pretty generally agreed, definition, then it can be said positively that in the greatest "productive industry," engineering, the value of science is fully appreciated. It is unnecessary in this place to name the numerous researches carried out by and for engineers or to refer to the scientific work that is performed daily in the development of inventions and the improvement of machines and processes. These things are well known to engineers and are reflected in the proceedings of their learned societies. If Professor Bernal is not already acquainted with the papers presented at the meetings of the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Iron and Steel Institute and the Institute of Metals—to name but a few bodies that represent productive industries—we invite him to glance through them. If he is acquainted with them he must in justice admit that all these institutions show by their work that science, in its broadest interpretation, is a continual preoccupation of their members. If, furthermore, he would study the discussions on scientific papers, he would be constrained to admit that they are not, nowadays, confined to a few professed scientists, but that a large and ever-increasing proportion of the members can follow intelligently and appreciatively purely scientific arguments. It may be, we shall not argue that matter at present, that conditions have brought about a demand for scientists—by whom we mean in this connection qualified engineers—greater than the colleges and universities can provide. It may be that some factories—not a few—are so completely absorbed in the business of production that they have no time and no occasion for any science other than that of shop routine and salesmanship. It may be that some firms are so pestered and be-badgered by labour problems, by controls, and Government forms that they have little heart for the pursuit of science. But though all this be allowed, it still remains an incontrovertible fact that the "science" of engineering is constantly expanding and that every important firm in the country—not invariably the largest—is already well served by its own scientists, and would justly resent the prying of an external State-directed body of professed scientists into its affairs.

And with what arguments does Professor Bernal support his proposal? The principal weapon in his armoury is "radar." His argument might be expressed thus: Since scientists did a marvellous thing in the rapid development of radar during the war, is it not reasonable to believe that they could do equally well for commercial productive industries? Our answer is definitely in the negative. Radar was a very exceptional case. It was fundamentally scientific, using that word for the moment in a familiar restricted sense, and its development took place under the advantages that a national emergency demanded. Industries are not carried on in that way. We agree that a productive system had in due course to be developed, but much of it is known to have been due to a progressive industrial company, and the rest of it followed upon industrial lines—see, for evidence, Sir Clifford Paterson's Presidential Address to the Institution of Engineers-in-Charge. But if radar be excepted, Professor Bernal advances only "varied problems of warfare and supply, and particularly the evolutions of the methods of operational research," which he believes could be "applied immediately" to coal production, economising of coal and power, improving transport and building and so forth. We should be in a better position to evaluate that proposition if Professor Bernal would make a precise statement of what methods *not already in use* his proposed committee of State scientists, with "directive and powers," would apply to those and other productive industries.

IMPROVISATION IN EMERGENCY

NEVER before had the present generation of engineers a greater opportunity to use its initiative than that forced upon it by the recent fuel and power emergency. With very little warning the life blood of modern industry, electric power, was cut off in this country and industry seemed to have no alternative but to shut down. Now, however, we are hearing accounts of how a large number of small, medium and even large works faced the problem and managed "to keep the wheels turning." In recent years it has often been suggested that the modern engineer is a specialist lacking in the comprehensive background and the ingenuity for adaptation for which his predecessors were famous. Now it has been demonstrated that the instinctive ability of the engineer to improvise and "make do" is not dead, but when the occasion arises he can still improvise, adapt and modify to use to the best advantage any power source available. The economics of the means adopted to keep plant running cannot be taken into account. For many of the highly specialised modern machines do not lend themselves to alternative means of driving. But the fact that even a relatively small amount of plant has been kept in production, instead of standing idle, has been to the good of industry even if only from the standpoint of morale.

During the late war much ingenuity was exercised to overcome the obstacles and delays occasioned by a shortage of plant, but rarely, if ever, was the primary source of power or heating not available. The current shortage of solid fuel for processing is obviously an insurmountable obstacle which no amount of ingenuity can overcome, and those works depending upon it have had no alternative but to shut down when stocks ran out. In other cases, however, the availability of a reasonable amount of petrol and oil fuel which could be used for driving engines of various types was seized upon as a saving factor and used to good effect in many establishments. Within a matter of hours in many works plans were evolved, and put into operation, whereby production plant and machines could be kept at work with alternative power, perhaps not economically, but certainly effectively. Mobile and portable generating sets were borrowed, bought or requisitioned from other jobs to supply current for power and light. Oil and

petrol engines and even tractors and lorries were laid down and adapted to drive line shafts, conveyors, &c. Portable air compressors, normally used for road work, were pressed into service to feed the air lines and replace blowers on forges and furnaces. These are but few of the many devices to which engineers have resorted in order to maintain production in their shops. To give a comprehensive list would be impossible, for the past few weeks provide an endless story of improvisation, adaptation and modification of which many executives can justifiably be proud.

There is little doubt that in many of the establishments where the management encouraged its engineers to make it possible for work to continue, a new understanding and appreciation of each other's qualities has come about between the engineering staff and the workers. Many old prejudices, suspicions and misunderstandings went by the board on both sides in order to make the emergency measures work. It became obvious to the worker that profit is not the only motive prompting the actions of management, and that the engineering staff can quickly drop its efficiency measures and improvise in order to tide over an otherwise bad time for the man in the works. The workers themselves responded well to the emergency measures, and often gave up hard-earned privileges to work under conditions which would not otherwise have been tolerated. Perhaps some good will arise out of this evil, for both engineers and workers have been put on their mettle, and where it was possible to continue work they were not found wanting.

Obituary

WILLIAM FENNELL

We have to record with regret the death, at his home, "Waverley," Sandiways, Cheshire, on Thursday, March 13th, of Mr. William Fennell, a director of the Mid-Cheshire Electricity Supply Company, Ltd., and the Mersey Power Company, Ltd. Mr. Fennell, who was seventy years of age, was educated at private schools and the Coleshill Grammar School, and received his technical training at the City and Guilds Technical College, Finsbury. In his last year as senior student he was assistant to the late Professor John Perry, and worked on electrical experiments. After leaving college he gained some experience in power station work and for some years was employed in the office of a consulting electrical engineer. In 1904 he was appointed the borough electrical engineer of Wednesbury, a position he held for the next ten years. He then became resident engineer for British Insulated Cables, Ltd., and from 1915 until 1918 was resident engineer with the North Metropolitan Electric Supply Company. In that year he was appointed engineer and secretary of the Northwich Electric Supply Company, an undertaking which at a later date became the Mid-Cheshire Electricity Supply Company, Ltd., of which Mr. Fennell became the general manager and engineer. From 1937 until his death Mr. Fennell was a director of the Mid-Cheshire Electricity Supply Company, Ltd., and the Mersey Power Company, Ltd. Fifty years ago he joined the Institution of Electrical Engineers and became a most valued member of that body. He was Chairman of the Transmission Section in 1935–1936, and in 1938–1939 he acted as Chairman of the North-Western Centre Committee. During those periods he also served on the Council. In 1945–1946 he was Chairman of the North-Western Transmission Group. He gave several papers on various aspects of electricity supply, and frequently took an active part in discussions. His last paper, which, in February, 1946, was read in London and the North Midlands Centre, was entitled "Fundamental Legislation for Electricity Supply to Consumers." His death will be widely regretted.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ELECTRICAL ECONOMICS

Sir,—Not being an electrical engineer, but merely a humble machine-tool maker, I write with a good deal of diffidence and I shall welcome criticisms from those better qualified than I am to deal with electrical matters.

In this crisis we are confronted with many problems, the most insistent of which are shortages of coal and of electric generating capacity. No amount of extra coal will produce current in excess of the capacity of existing generating plant. On the other hand, additional generating plant would be useless in the absence of sufficient coal to keep it running. Industry needs coal for many purposes, besides the production of electric current; among others to keep our workshops at reasonable temperatures (though on this point, I believe we can, with advantage, reduce internal temperatures considerably below those to which we have grown accustomed in times of plenty).

Domestic users of current have been dazzled by the prospect of "all-electric homes," equipped with heaters, cookers, refrigerators, water heaters, Hoovers, electric irons, and so forth. Very naturally, they, or the authorities who have provided the new houses for them, have not hesitated to install these very convenient devourers of current, and they are used with alarming prodigality. Domestic consumption has, consequently, grown to such an extent as seriously to interfere with industrial needs, and it should obviously be restricted. Gas, which is much more economical than electricity for heating and cooking, should be used in new houses, and the flood of electric cookers and heaters should be largely diverted to export.

While we may still hope for better times ahead, when our nationalised coal mines give us abundant supplies and when our electrical engineers have overtaken their arrears in the provision of generating plant, yet it is very obvious that in the meantime we must face a long period of shortage. We are bound, therefore, to consider every possible means of economising in the consumption of current and of reducing the demands on our electrical engineers, whose order books are so overloaded as to make their deliveries extremely unsatisfactory.

Engineers, and machine-tool makers in particular, have developed the individual driving of machines with a somewhat lavish hand. Until recently there has been no shortage of current nor of electrical appliances, while the extra cost of individual driving, both in capital expenditure and in power consumption is, in normal circumstances, more than balanced by its undeniable advantages.

Individual driving has, moreover, been encouraged by fashion, to the dictates of which engineers are almost as susceptible as their womenfolk. With individual driving, machines may be put down in any convenient position; they may be easily and quickly rearranged when necessary, and there are no overhead obstructions to cranes or lighting, while the appearance of an all-electric factory is very attractive.

It is, beyond question, however, that individual driving is extravagant.

By reverting to the earlier practice of arranging machines in convenient groups and driving each group by a line-shaft with its own motor, considerable economies are possible. The following comparisons, taken from groups of machines in our Coventry works are, I think, instructive. The figures have been somewhat hastily compiled, but they are within reasonable limits of accuracy.

One group comprises thirteen milling machines. If these machines had been fitted with standard electric individual drives, thirteen motors would have been required: two 3 h.p., nine of 10 h.p., and two of 15 h.p.—a total of 126 h.p., and these motors, with their starters, push button controls and other accessories would have cost £836. The group is actually driven with a quite satisfactory margin by one 25 h.p. motor, which, together with starter and line-shaft, costs approximately £390. There is thus a capital saving in favour of the group system of £446—well over 50 per cent.

When a machine is individually driven it is obviously necessary to equip it with a motor capable of taking its maximum load. In practice, however, few machines are working at maximum capacity, except for very brief periods, and it never happens that any large number of machines in a group are working at full capacity at the same time. In this group experience shows that the one 25 h.p. motor is ample. It may be observed that nearly all these machines are engaged on comparatively light work.

So much for capital cost; now let us consider current requirements. Without rather elaborate tests, it is difficult to assess this accurately, but it is common knowledge that a motor running regularly at something near its normal full load is very much more efficient than a number of motors running at one-third or one-quarter load, and I think it may be safely assumed that the power consumed would show a saving of from 15 per cent to 30 per cent in favour of group driving.

Another group of seven machines (turret, capstan and auto lathes) is driven by one 25 h.p. motor and line-shaft with an average power consumption of about 16 h.p. If individually driven, seven motors of a total rating of 60 h.p. would have been required.

In still another instance we have a group of fourteen lathes driven by line-shaft and one motor with an average power consumption of about 12 h.p. Had these machines been provided with individual drives, fourteen motors, totalling 70 h.p., would have been fitted.

In both of these latter groups the saving in capital expenditure and in power consumption would be of the same order as in the first group.

Other firms in Coventry are already changing over some of their machines to group drive,

and I believe the subject is worth very careful consideration by others. Most electrically equipped machines have motors which can be disconnected and replaced by belts without much trouble or expense. On the other hand, where electrical equipment is actually incorporated with a machine, where stopping, starting and speed changes are electrically controlled, and where auxiliary motors are fitted to drive feed motions and pumps, conversion would be inadvisable.

Now we come to another question, which is less simple and on which I am even less qualified to write, but which, none-the-less is of importance in the search for economy. Electrical engineers agree that a good electric power factor is highly desirable. Electric circuits should be watched and if their power factor should fall below the optimum, then condensers should be introduced. In our Coventry works we have installed a number of condensers, which have effected considerable economies by reducing our peak load.

ALFRED HERBERT.

CONDENSING BY COMPRESSION

SIR,—In response to requests for a heat balance in connection with the above subject, and in view of the points raised in Mr. Oliver Lyle's article on "The Compression-Condensation Cycle," appearing in THE ENGINEER of January 24th, I submit the following, based on the data given on page 203 of the September 6th issue, and taking the mean of tests Nos. 7, 8 and 9, and Nos. 5, 10 and 11 as three stable periods of working under each condition.

	Atmospheric working	On system
Coal rate, lb/hr.	510·0	343·0
Boiler pressure, lb/sq in (gauge)	153·8	152·3
Exhaust back pressure lb/sq in (gauge)	1·0 (approx.)	6·4
Temperature of feed, deg. Fah.	50·0 (approx.)	228·0
Net output of plant in E.H.P....	84·7	82·6

To this it can be added that the E.H.P. taken by the compressor motor was 2·89, of which 1·68 was absorbed in friction and electrical losses, so leaving 1·21 as the horsepower expended in compression. Observations taken under a wide range of power output while working on the system gave results which, when plotted as points, followed a straight line law, $s = 81·7 - 0·524e$, where s = lb of steam per net electrical horsepower hour, e. In the case of an output of 82·6 E.H.P. the total steam is estimated at 3170 lb per hour.

The following table can now be filled in :—

	Atmospheric	On system
Net electrical output	84·7	82·6
E.H.P. for compressor	—	2·9
E.H.P. generated	84·7	85·5
B.H.P. at 83 per cent efficiency	102·0	103·0
I.H.P. at 90 per cent efficiency	113·3	114·5
Total steam per hr. in lb	2790	3170
Steam in lb per i.h.p. hr.	24·6	27·7
Heat as work, B.Th.U./lb... ...	103·5	92·0
Available adiabatic heat drop, B.Th.U.	174·1	154·5
Engine efficiency ratio	0·595	0·595

Working down the right hand column, an engine efficiency of 59·5 per cent is estimated. Transferring this figure to the left hand column and working upwards gives the steam per i.h.p. hour and total steam for atmospheric working. The constants are chosen for a generating set working at 70 per cent of its full rated capacity.

The boiler and feed account is then as follows :

	Atmospheric	On system
Total B.Th.U. in steam per hour	(2790×1197·1) =3,340,000	(3170×1197·0) =3,790,000
B.Th.U. from feed	(2790×(50−32)) =50,000	(3170×497) =1,575,000
B.Th.U. from coal	3,290,000	(3,290,000 ×343/510) =2,215,000

The heat given up to the steam by the combustion of 510 lb of coal per hour is 3,290,000 and pro ratio the combustion of 343 lb on the same grate gives up 2,215,000 B.Th.U. Therefore the feed has to carry 497 B.Th.U. per lb or 298 B.Th.U. above the heat of water at the temperature of delivery. The evaporative figure of 2790/510 = 5·5 is somewhat low, but this is because the boiler normally supplied two generating sets and was therefore working at less than half its rated capacity.

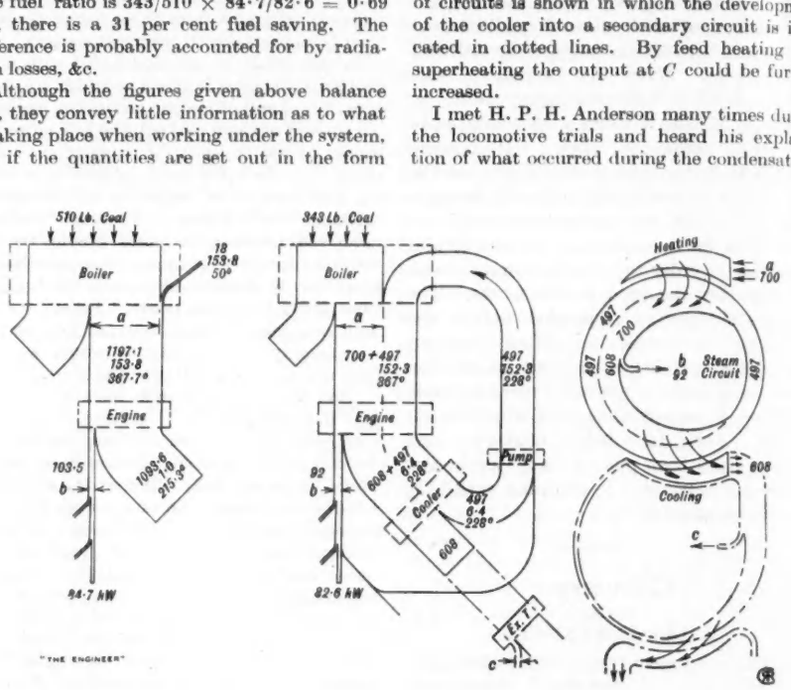
The engine and cooler account is as under :—

	Atmospheric	On system
Total B.Th.U. to cylinders ...	3,340,000	3,790,000
Heat appearing as work ...	289,000	291,500
B.Th.U. in exhaust (by diff.)	3,051,000	3,498,500
B.Th.U. to feed	—	1,575,000
B.Th.U. rejected	3,051,000	1,923,500

The ratio of the heat rejected in the two cases is, for equal outputs, 1,923,500/3,051,000 × 84·7/82·6 = 0·647, so that a 35·3 per cent saving in heat is effected by condensing. The fuel ratio is 343/510 × 84·7/82·6 = 0·69 i.e., there is a 31 per cent fuel saving. The difference is probably accounted for by radiation losses, &c.

Although the figures given above balance out, they convey little information as to what is taking place when working under the system, but if the quantities are set out in the form of a heat energy stream, the result is most illuminating. By reference to the diagram, it is seen that the stream through the engine is really in two parts, one stream in the form of a continuous belt of constant heat content, which circulates through the engine, cooler, compressor and boiler, and the other a stream of heat from the combustion of fuel passing through the engine of which the portion not converted into work is rejected by means of the cooling medium. Apparently what the inventors have achieved is to so manipulate this endless stream that it passes through its various phases without change of energy, like a wave. This explains why no large amount of external work is required in compression ; only a small amount is expended at the pump, whose function now appears to be more that of a circulator. This stream of heat has to be maintained against radiation, hence a small percentage of the heat of the fuel consumed must be used to make good the wastage, and the 31 per cent saving of fuel includes this loss.

According to the weight of steam passing through it, there is no improvement in the efficiency of the engine while working on the system, but rather the reverse, owing to higher back pressure. Measured as the amount of work done in relation to heat supplied by the fuel, b/a on the diagrams, the efficiency of the plant has been improved by nearly 50 per cent, compared with atmospheric working.



The inventors claimed, however, that it is possible to return 70 per cent of the heat in the steam at boiler pressure in the feed before pumping becomes uneconomic, in which case much higher efficiency is attainable by scientific research and refinement in design.

In the locomotive experiment cooling was effected by evaporating water at 212 deg. Fah., so producing low pressure steam. By the application of an exhaust steam turbine further work can be extracted from this tail race of the power plant through the normal means of condensing down to a 29in vacuum. In this case the cooler develops into a secondary steam generator fed by condensate at, say, 70 deg. Fah., and producing steam at 212 deg. A two-stage system is thus set up whose efficiency is $b + c/a$ on the diagram, a further increase. To make this point clear, a diagram of circuits is shown in which the development of the cooler into a secondary circuit is indicated in dotted lines. By feed heating and superheating the output at C could be further increased.

I met H. P. H. Anderson many times during the locomotive trials and heard his explanation of what occurred during the condensation-compression cycle, which may be summarised as follows : Exhaust steam has part of its heat abstracted in a cooler of diminishing cross-sectional area, so forming a heavy mist or "emulsion" of steam and water, which gravitates to the pump, situated well below the level of the cooler, so that the combined effects of steam pressure, head and velocity maintain some degree of compression. Further reduction in area occurs in the pipe connection and the treated steam flows into the pump barrel at the end of the suction stroke. The rising piston reduces the volume without any appreciable effort—it does not behave as a gas—until the piston is nearly at the end of its stroke and the contents have been reduced to liquid form. The piston then lifts the delivery valve with the liquid in a thin layer between them and ascends into the high pressure zone. The heavy load imposed by boiler pressure on the large diameter of the valve is easily overcome by the toggle action of crank and connecting rod near the top dead centre. Under the spring-loading the delivery valve forces out the liquid and makes contact with the piston. On the return the valve is seated and the piston descends to take in a fresh charge. The liquid delivered is apparently hot water with steam in solution, and by the constraint enforced by the feed pipe, it remains in this condition until it meets the hot water in the boiler and reactions occur.

If the exhaust steam is not treated in the

manner described, steam and water separate out of the mixture, which becomes unpumpable—at least, with the small power provided.

H. HOLCROFT.

Chipstead, Surrey.
February 1, 1947.

BURNING SLACK ON OPEN HEARTHS

SIR,—Your correspondent, Prior Lien, and others, may be interested to know the way in which my wife solved the problem of burning slack on our open hearth. On her suggestion, I had made a steel grid floor for the coal store. This must be at least 12in from the solid floor, so that when the coal is tipped the slack falls to the solid floor and can be used simultaneously with the large coal. The grid is of welded steel flats, 2½in by ⅜in in a frame, with steel legs to raise the grid floor 12in from the solid floor, and so leave space for shovelling the slack. With the steel flats at 1½in centres, we find that a good mixture of rough and fine slack is available, and what is perhaps more important, the slack is available at the same time as the larger coal, instead of, as is usual, after the large coal has been used. As an accessory, I made a long-handled scraper to reach to the back of the coal store under the grid, and this ensures that all the slack is available. We have had no difficulty in using up our slack since the grid was installed two years ago.

E. E. BOOKER.

Birmingham, March 14th.

THE GREAT FROST

SIR,—I have read the contributed article, "The Great Frost," in your issue of March 14th, with interest.

Without doubt, the article is against the present Government and planned economy. Naturally, your contributor will not disagree with planning, as engineers, apart from being the "strong, silent men" who work and think hard, as your contributor so colourfully describes them, are, above all, planners. This, of course, is elementary, and we have only to think of Ford's and Nuffield's organisations to realise this fact. Of course, it comes down to the question of planning for whom. Your contributor, no doubt, objects to planning by politicians. I make bold to suggest that he was in agreement with Mr. Churchill's planning during the war.

It is, however, generally accepted that to-day's economic crisis is on a parallel with the crisis of the war years. If this is true, does he suggest that materials and industry should be released from control and a free-for-all scramble for quick and profitable sales, regardless of social commitments, ensue? The writer must be thinking he is living in pre-war days. Surely, apart from expediency, it is a question of social conscience. We cannot expect the masses of the population, who are, incidentally, the electoral majority, to be satisfied in suffering extremely expensive and scarce food, clothes and houses, while industrialists sell in the most profitable markets. This is the fuel for revolution. Free competition worked well up to a point before the war, when materials and labour power were cheap and plentiful. Even so, industry found it necessary to curb free competition in those days, as the scramble for orders and the consequent cutting of prices tended to leave no profit margin. Therefore, industry, in self-defence, undertook its own sectional planned economy.

To my way of thinking, it appears inescapable that, owing to short supply of materials and labour due to the ravages of war, a planned economy is necessary, however distasteful. It used to be a dictum in pre-war days that we live by export due to being an industrial nation, and also due to our inability to feed ourselves without imports. That obtains to-day in a far greater measure, due to the loss of our overseas investments. How does your correspondent suggest this problem should be solved other than by planning? Such phrases as initiative, hard work, no fetters and deep thinking, are useless unless correlated in one overall plan which will bring this great country safely out of the disaster caused by the greatest war in history which created the greatest wastage of plant and industrial skill the country has ever experienced.

I would suggest that more and better planning with targets and incentives is the only sane way to prosperity.

BELL.

London.

LOCOMOTIVE VALVE GEARS

SIR,—At the risk of being considered unduly pedantic, may I emphasise that Dr. Tuplin in his original article referred to it being a characteristic of Stephenson's gear that it gives negative lead in full gear. That is not a characteristic of Stephenson's gear any more than it is of Walschaerts, for that matter any other normal valve gear, for they can all be set to give a negative lead in full gear. The characteristic in which Stephenson's gear, and to a lesser extent, Allan's, differ from most other gears in common use is in the automatic advance in the valve timing which they provide as they are moved from full to mid gear. Negative lead in full gear is not a characteristic of Stephenson's or any other gear, but a particular form of valve setting designed to take advantage of the special characteristic referred to. Mr. Holcroft's excellent letter in your issue of January 24th makes the point abundantly clear.

K. N. HARRIS.

Wealdstone, February 12th.

NIGHT VISION BY INFRA-RED RADIATION

SIR,—I was very interested in your article in THE ENGINEER, of February 14, 1947, with relation to night vision by infra-red radiation. As early as January, 1941, during that desparate bombing winter, I proposed to the Air Ministry the use of infra-red radiation for night vision for aircraft by the use of tungsten filament searchlights, with light filters on the aircraft, combined with electron detector telescopes, having transparent sensitised cathodes, electrical magnification lenses, and prepared sight screens to form the electron image received from the cathode. Electron tubes sensitive to infra-red radiation were available in 1937, and it would appear that they could be used as the detecting and image-forming elements in any scheme of night vision. The device that I proposed was in the form of a reflector telescope, or periscope, operated electrically through the roof of the pilot's cabin, enclosed in a vacuum tube like a thermos flask, and air-conditioned to prevent condensation, and a detector device, comprising an electron infra-red telescope with a transparent cathode, sensitised with caesium on silver oxide, with an electrically controlled lens for magnification of the electron image from the cathode, and an optical screen of Willemite (zinc silicate), for reproduction of the electron image from the cathode into visible form. A suitable optical device to correct the inverted image, and give optical magnification would be fitted. To-day the device could be made into a more efficient night vision apparatus by magnification of the electron image by television apparatus. I feel that the day is not far distant when infra-red night vision will give to our airmen, anti-aircraft batteries, and our seamen clear vision. The aircraft exhaust, rich in infra-red radiation, would bring a clear vision to this apparatus.

JAMES R. FISH.

Bolton, March 9th.

L.N.E.R. Marshmoor Derailment Report

THE report of Lieut.-Colonel G. R. S. Wilson, who was assisted by Brigadier C. A. Langley, to the Minister of Transport, on the derailment which occurred about 10.35 p.m. on Sunday, November 10th, 1946, near Marshmoor signal-box, between Hatfield and Brookman's Park, on the L.N.E. Railway, has now been published by the Stationery Office.

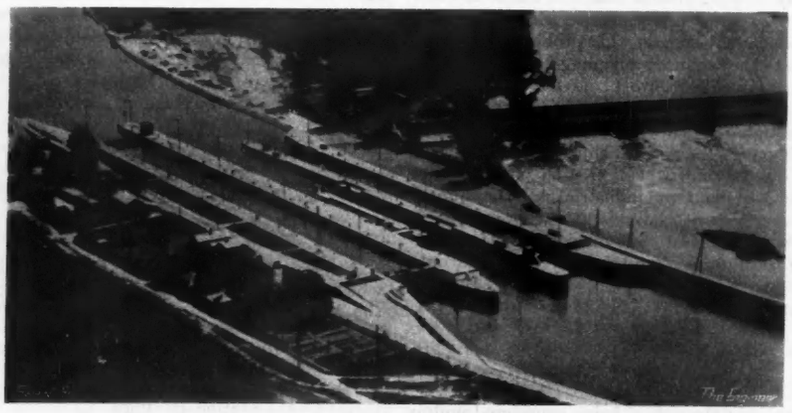
It will be recalled that the 4.45 p.m. express passenger train from Newcastle to King's Cross, comprising twelve bogie vehicles, hauled by a 2–6–2 type tender engine of the "V.2" class, was travelling on the up main line when it became completely derailed, except for the leading pony wheels, as it entered an east right-hand curve approximately 400 yards south of Marshmoor signalbox. The train was lightly loaded and fortunately there were no serious casualties.

Sections of the report deal fully with the state of the track and the measurements made by the inspectors and with the examination of the engine and train. Evidence was taken from the drivers of five up express trains which passed the site on the up main line during the hours preceding the derailment. All the evidence suggests that the foundation of the up main track at Marshmoor had not been fit for unrestricted running, even at 60 m.p.h., for some time.

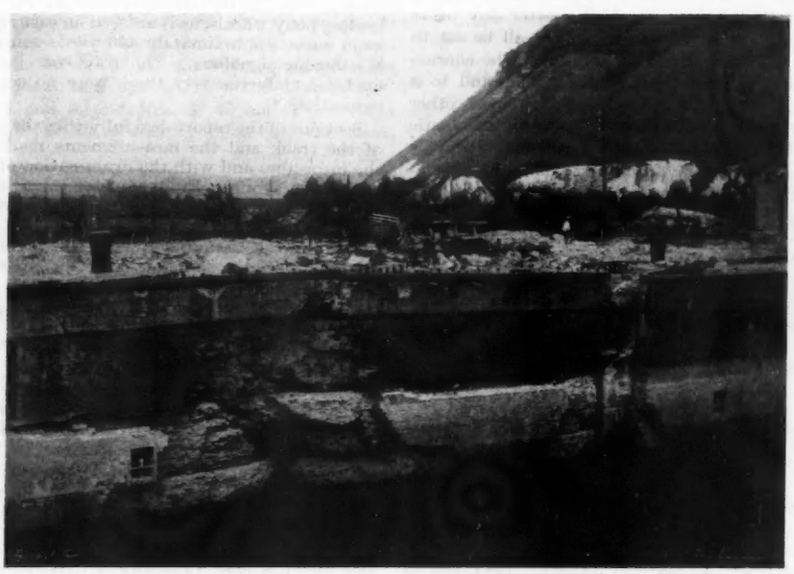
In the conclusion of his report Colonel Wilson says that, though track defects were the primary cause, the Marshmoor derailment and that at Hatfield, when considered in conjunction with previous derailments of engines of the "V.2" class, have drawn attention to their behaviour in relation to such defects, or even to comparatively minor imperfections in alignment and cross level. Improvement of the pony truck side control was recommended in Colonel Wilson's report on the Hatfield case, and the L.N.E.R. Company is experimenting in this direction and has already abandoned the swing-link arrangement in favour of spring control where new designs are concerned.

A number of engines of the "V.2" class are being fitted with a spring-controlled pony truck, similar to the new 2–6–4 type tank engines, and the weight is taken by side bearing pads; there will thus be some damping effect, and the arrangement, Colonel Wilson says, should result in a more satisfactory distribution of the flange forces, particularly as the springs can be set to provide some initial control. Maintenance should be simplified. One engine has been altered in this way and twenty-five more will be dealt with as the necessary equipment, now on order, becomes available. After trial on a considerable scale, and when it is proved in service a decision will be taken on the alteration of the remaining engines of this class. As a longer-term policy the company is building a number of "Pacific" type engines, some with 6ft 8in diameter wheels and others with 6ft 2in coupled wheels, which will enable a corresponding number of "V.2" class engines to be released from express passenger work. Meanwhile a restriction of 20 m.p.h. has been imposed at Marshmoor pending completion of drainage work, and also at several other points including Hatfield, on the main line south of Doncaster. Special attention is being given to these weak points, which are largely the result of arrears of maintenance during the war.

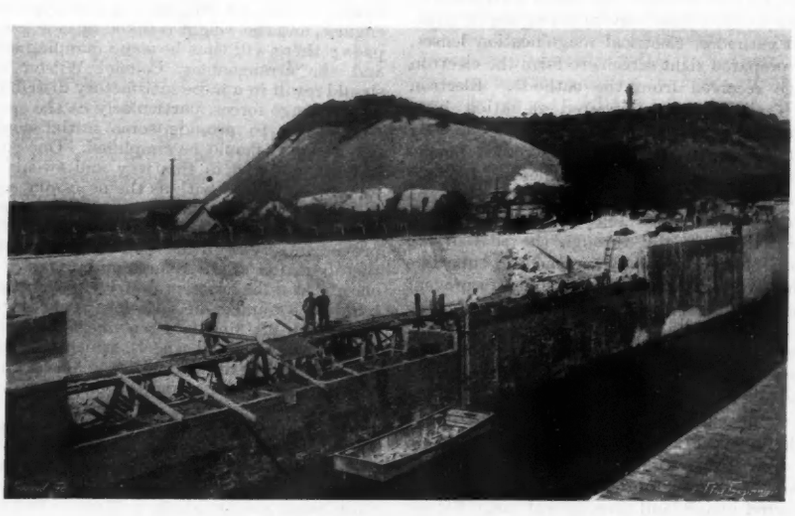
AMFREVILLE LOCKS AND POSES WEIR



LOCKS AND WEIR AT AMFREVILLE BEFORE DESTRUCTION



WRECKAGE OF SIDE WALL



REBUILDING SIDE WALL

Reconstruction of Amfreville Locks, River Seine

WITH reconstruction completed of Amfreville locks, the largest and most modern on the Lower Seine, the river is now equipped with locks at each end of the lower navigable channel.

The main Amfreville lock, which was constructed in 1931, had a depth of 4·75 m to 5 m in the upstream channel. The foundations were laid partly by compressed air on reinforced concrete rafts, and partly on drained trenches surrounded by sheet piling walls. The side walls were in reinforced concrete with a facing of bricks, but the bottom of the lock was of simple dry-jointed paving. There were two moving gates, electrically worked, power being derived from a 16,000-V transformer. The lock was 220 m long and 17 m wide. The original appearance of the locks and Poses weir is illustrated herewith.

In July, 1944, an Allied bombardment completely destroyed the transformers and at the same time the right wall of the main lock was shattered for a length of 80 m, and there were numerous craters in the neighbourhood. In August, 1944, the Germans destroyed part of the mechanism and electrical apparatus. The second lock was not spared, but damage was less serious, and repairs carried out enabled navigation to be re-established in October of that year. The weir

DOWNSTREAM LOCK GATE AFTER REPAIR

at Poses was also damaged, making it impossible for the level to be maintained in the upstream channel, and during the winter 1944–45 all efforts were directed to its repair. When this work was at last complete, in April, 1945, attention was turned to the lock.

Repairs were divided into three different operations. The first was the clearing of the ground behind the damaged part of the wall, and demolition of the masonry split by the explosion. Luckily, pumps were available to aid in this work. For the second phase of reconstruction a contract was let for 2200 cubic metres of earthwork, 1100 cubic metres of masonry and cement, 980 cubic metres of reconstruction in reinforced concrete, and 160 cubic metres of brick facing. Finally, the repair of the gate operating mechanisms was undertaken. Blue prints were still available, but there was considerable difficulty in obtaining the steel parts necessary.

In November, 1945, the earthwork was started, a 500 litre mechanical shovel being used. In the second stage of demolition a 50 h.p. compressor was used by the contractor to operate five drills. In February and March, demolitions continued, at first up to the downstream level. Then five electric pumps were put simultaneously into action, so as to finish the de-watering as quickly as possible. By May the brick facing was laid, reinforced concrete being poured as the brick work proceeded. The work was completed by filling in the excavation behind the wall, and by the installation of machinery. With the means available, it was no easy task to lift the gates, for the downstream gate weighed 200 tons and the upstream gate 100 tons.

Industrial Applications of Electronic Techniques*

By H. A. THOMAS, D.Sc., M.I.E.E.

Introduction

To industry, in general, electronic engineering has been associated with communication and entertainment and, prior to about 1935, the application of electronic principles in the industrial field was, save for the most elementary purposes, confined almost entirely to the radio and light electrical engineering industries. Under the stimulus of war, enormous progress has been made in communication engineering and in radio applications of electronic principles, but only slight application of electronic techniques appears to have taken place in general industry. This is due primarily to the fact that many industries have not yet been made aware of the versatility of this new branch of engineering.

During the present reconstruction period a maximum effort should be made to obtain the highest standard of industrial efficiency with reduced manpower. The possible applications of electronic techniques for this purpose are innumerable, considerable improvements being possible in the production, inspection, testing and marketing of products if adequate consideration be given to the numerous opportunities afforded.

The sole object of this paper is to stimulate interest in the application of electronic techniques to industry. As a first step the author has attempted to present a digest of some of the industrial applications of electronic techniques which have been developed during the past few years and to indicate possible new fields of application.

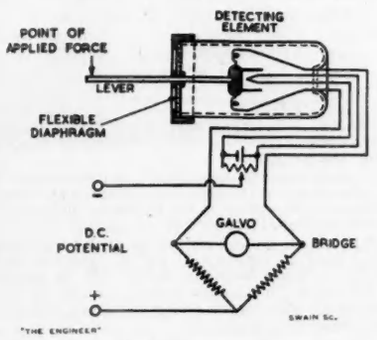


FIG. 1—*Gunn Micrometer*

Scope of Electronic Techniques

An electronic technique may be defined as one involving devices which function by virtue of the control of the motion of free electrons. Thermionic valves of all types, photo-electric cells, gas rectifiers, cathode-ray and X-ray tubes are obvious examples, and any technique involving their use may be classified as electronic. There are a number of devices, such as photo-voltaic cells, magnetostriction and quartz crystal oscillators, high-frequency generators for eddy current and dielectric heating, &c., in which the motion of free electrons is not the essential feature, but which nevertheless are usually classified as electronic because these devices are associated in some manner with valves, photo-electric cells or cathode-ray tubes.

The essential feature of all such devices is that moving electrons possess so little inertia that their motions can be controlled by the expenditure of negligible energy and with negligible time delay. For instance, in the thermionic valve electric power is controlled by electric potential, in the photo-electric cell electric power is controlled by light intensity, and in the cathode-ray tube the motion of a fluorescent spot is controlled by electric potential or magnetic flux; in each case response to the controlling agent is practically instantaneous and the energy required to effect control is negligible.

The principal industrial applications of electronic devices lie in the following fields:—

Measurement,
Industrial instrumentation and control,
Production,
Inspection, and
Protection,

and this broad classification will be adopted in the paper.

Measurement

Introduction.—Before a variable in an industrial process can be controlled it must first be measured. Electronic developments in the field of measurement have been so startling during the past two decades that not only have improved methods been developed in practically every sphere of measurement, but entirely new techniques have been evolved for measuring physical quantities which previously could be measured only by slow and laborious methods. Among these latter may be mentioned instruments such as absorptiometer, density meter, colorimeter, turbidity meter, titration indicator, smoke detector, aeration meter and moisture meter.

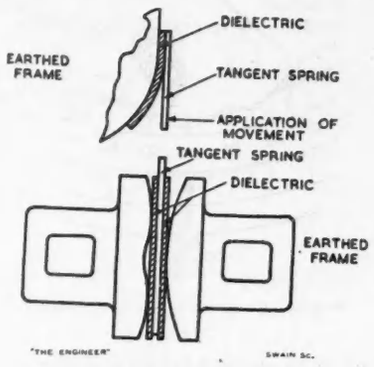


FIG. 2—*Capacitance Strain Gauge*

Little consideration will be given to the application of electronic techniques for the measurement of purely electrical quantities where their use is now well known. Attention will be confined almost entirely to the application of those techniques in fields of measurement which are less well known, but are of importance in industrial processes.

In general, measurement of a physical quantity can be achieved in one of two ways: either the effect of variation in the quantity under measurement on some physical property of a measuring detector can be utilised directly to produce some effect evident to the senses, or alternatively the quantity being measured can be compared directly with a known but variable quantity of the same nature, the process of measurement in this case involving means whereby equality between the two quantities can accurately be assessed. Obvious examples of the former method are the spring balance, thermometer, barometer, ammeter, tachometer, &c., and of the latter the scale balance, measuring rule, micrometer, potentiometer, current balance, &c.

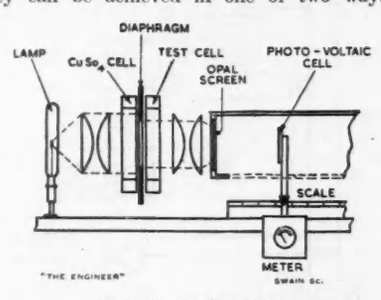


FIG. 3—*Opacity Meter*

In every practical case variation of the parameter produces some physical change in the detecting element—expansion, electrical resistance, position, &c.—and this change is of small magnitude. Examination of the nature of such elements as used in about fifty typical modern instruments shows that in all cases measurement ultimately resolves itself into magnification and subsequent observation of either a small mechanical displacement or a direct or alternating electric current.

If electronic methods are to be used to provide this magnification it is essential that the detecting instrument shall first convert the parameter under measurement into an electrical change. The electrical change so produced may operate an indicator directly, or may be amplified to a level sufficient to operate such an indicator.

Means of Converting Small Mechanical Displacement into Electrical Change.—A method which has made considerable progress recently for measuring strain in mechanical members is the use of fine-wire resistance elements,[3] the electrical resistance of which is a linear function of length. The elements usually consist of 0·001in nichrome wire wound on a loop of thin resin-impregnated paper; nichrome strip leads are spot welded to the wire. Outer sheets of paper are bonded by heat and pressure to make a laminated sheet about 0·005in thick. The strips when completed are usually about 1in by 0·6in and the resistance about 2000 ohms. When such strips are glued to a roughened and clean surface any strain in the member is communicated to the strip, thus giving rise to a corresponding resistance change. The "strain sensitivity," or ratio of fractional change of electrical resistance to fractional change of length, is about 2·2 and is constant for strains not exceeding one-half of 1 per cent.

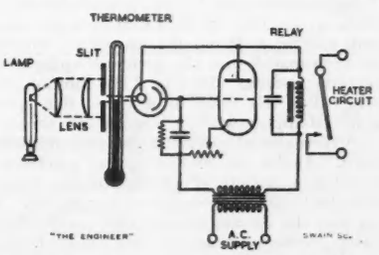


FIG. 4—*Mercury Thermometer Thermostat*

The usual method of applying this technique is to glue gauges to a number of points on to a mechanical member undergoing examination; each gauge is switched in turn into a bridge system employing a compensating resistor consisting of an identical gauge glued to an identical unstrained member at the same temperature. With a current of 5 mA and a sensitive out-of-balance detector very high sensitivity is obtainable with good zero stability; the upper frequency limit is about 50,000 c/s.

A very simple method of measuring small movements without imposing appreciable constraint upon the actuating member has been described by Gunn[20] and is illustrated in Fig. 1. The detecting element consists of two light metal anodes rigidly connected together by a ceramic or glass bead which in turn is fixed to the end of a light lever supported by a flexible diaphragm. The anodes are arranged to be equidistant from a heated filament and are enclosed in an evacuated glass envelope with light, flexible connectors. The two diodes so formed are arranged in a balanced d.c. bridge circuit. If a light force is applied to the exposed end of the lever the resistance of one diode is increased while that of the other is decreased; the consequent out-of-balance current is used to indicate the mechanical movement. The zero stability of such a system is very high, the natural period of the lever can be made 10,000 c/s, and the sensitivity 150 μA/0·001in deflection, or 0·5 volt across an indicator of 3000 ohms resistance.

The previous methods all impose some constraint on the moving member; in many cases this constraint is inadmissible. A method employing resistance-change which imposes no constraint on the moving member has been

* Abstract. Institution of Electrical Engineers, January 16, 1947.

developed by the author.[39, 40, 41] In this method a simple radio-frequency oscillator is used in which the tuned circuit inductor takes the form of a very small, flat coil about ½in diameter and ⅛in thick; by mounting this coil rigidly about ¼in away from a metal plate eddy currents are produced in the plate and the radio-frequency resistance of the tuned circuit is increased. Movement of the plate varies the radio-frequency resistance and in consequence the voltage swing on the grid of the valve; this variation in turn affects the mean anode current which is observed on a milliammeter. The sensitivity is very high—about 2 mA/0·001in—and linearity is obtained over a range of about 0·006in. The range over which linearity can be obtained is dependent upon the dimensions of the inductor; if this is large, a range of 0·5in can be achieved but with reduced sensitivity.

The metallic member employed may take the form of a small vane of any metal and may consist of only a small piece of foil glued to the member under observation. Since there are no constraining forces, no contact and no frequency limitation, this method is particularly valuable in a large number of cases. It has been used for measuring movements and vibrations of the order of 10^{-9}in and has been adapted for direct recording of strain in heavy engineering members.

Variation of capacitance by movement of one electrode of a capacitor can likewise be utilised to produce frequency change in an oscillation system. At radio frequencies very great sensitivity can be achieved, but it is difficult to obtain linearity over an appreciable range.

In applications where some constraint on the detecting member is permissible, such as in strain gauges, it is possible to obtain linearity over a reasonable range by correct shaping of the electrode system.[8] In Fig. 2 the moving electrode takes the form of a light, flat spring rigidly clamped with a separating sheet of dielectric material to a fixed electrode shaped as shown. Deflection of the spring produces a capacitance change which is strictly proportional to the deflection of the spring tip. By adopting the arrangement shown in the lower sketch greater sensitivity can be achieved—10 μμF/0·001in, linear over a range of 0·0016in. As before, the frequency change obtained by variation of capacitance can be converted into current variation by a number of standard methods.

Means of Converting Light-Intensity Variation into Electrical Change.—An important group of electronic measuring instruments makes use of variations of light intensity which are converted into electrical changes by a photo-electric or photo-voltaic cell.

Photo-electric cells are now used for measuring opacity of solutions in chemical analysis. A typical arrangement[13] is shown in Fig. 3; light from a lamp source is passed through a filter consisting of a 4 per cent solution of copper sulphate to reduce infra-red radiation. The test cell is interposed and the illumination on an opal screen is measured by a photo-voltaic cell. Concentration of the test solution is measured by reference to calibration charts obtained previously from known samples.

Electrical Variations Used Directly in Electronic Techniques.—Any direct electrical change produced by variation of a physical parameter can be utilised for measurement. Measurement of temperature by the use of thermo-couples, the conductivity of solutions by use of fixed electrodes, air speed by use of hot wires and humidity by use of hygroscopically-sensitive conductors are examples of this type.

In one type of electrical hygrometer[25] the detecting element consists of paper impregnated with potassium acetate; a change of resistance of 10–100 megohms occurs from wet to dry. In another type a strip of muslin is impregnated with calcium chloride, and the alternating current obtained when an alternating voltage is applied is measured on a meter calibrated directly in percentage relative humidity.

Variation of the dielectric properties of a material may be utilised for measuring moisture content. Such an instrument has been developed by Hartshorn and Wilson[22] for measuring directly the moisture content of materials such as grain, seeds, tobacco, wood, wool, &c. The sample is put into a special container so arranged that the material forms the dielectric between two electrodes of fixed dimensions; the test cell so formed is supplied with alternating potential and the losses in the dielectric produce phase changes which, by use of an a.c. bridge valve network, can be made to give an indication on a current meter. Calibration scales for different materials are supplied, so that the instrument is direct reading.

Another application of dielectric change is the aeration meter for measuring the air content

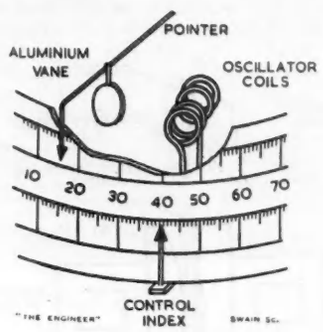


FIG. 5—*Non-Contact Deflection Detector*

of oil in an engine lubricating system under dynamic conditions.† The meter consists of an a.c. bridge in which a capacitor is arranged in the oil feed pipe to the engine; since the permittivity of the oil is a function of the air pressure, the indicating arrangements can be calibrated directly in terms of the percentage volume aeration.

Industrial Instrumentation and Control

[The author prefaced his remarks on this subject by differentiating between an industrial measuring instrument and an industrial control system, describing the essential components and requirements of each; he also discussed the difficulties associated with electrical contacts when they form a link in the chain of operation of a control system.]

Control Methods When the Detecting Element Produces Mechanical Deflection.—One of the simplest methods of avoiding the difficulties

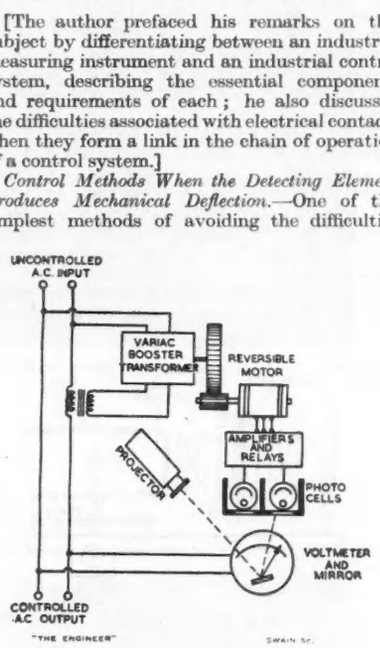


FIG. 6—*Photo-Electric Voltage Stabiliser*

inherent with electrical contacts is to permit the moving member to interrupt a light beam and so operate a circuit by aid of a photo cell. This method has been used extensively, and by correct design of the optical system can be made very sensitive. It has been applied to control temperature, using a mercury thermometer as the detecting element[46] (see Fig. 4).

Another simple method which imposes no load on a delicate moving element is to permit movement of a light metal vane attached to the element to change the capacitance or resistance of a radio-frequency circuit. The principle has already been described above. A particular form used with a pointer instrument[59] is illustrated in Fig. 5. The index pointer carrying the split oscillator coils can be preset, and when the aluminium vane reaches a certain position in the radio-frequency field the anode current in the associated valve circuit drops suddenly and operates a relay. As already shown, operation can be made to take place with movements of the order of 0·001in.

The methods so far described close or open an electrical circuit at a preset deflection of a mechanical member. Closure of the circuit in turn controls either the indicating instrument or the agent controlling the parameter. Such systems must therefore always "hunt."

Better control is possible by the use of systems having a stable condition. When the detecting element produces a mechanical deflection, systems can be developed using balanced detectors, the electrical outputs of which are used to operate the controlling agency. One example of such a device is illustrated in Fig. 6 for giving a stabilised voltage output of reasonable power.[34] In this case a light mirror is attached to the moving pointer of a voltmeter connected across the output terminals. Light is reflected on to two photo cells arranged to operate a reversible motor geared to a Variac booster transformer. Stability is attained when the currents from both amplifiers are identical and the motor is at rest, this occurring only at one preset voltage. Any disturbance to the system produces rotation of the motor in the direction necessary to correct the voltage change. It is claimed that control to within one part in 1000 is possible.[34]

† D. Napier and Son, Ltd.

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(To be continued)

BRITISH INSTITUTE OF MANAGEMENT.—The President of the Board of Trade has now announced the names of those who have agreed to serve on the first Council of the British Institute of Management, under the chairmanship of Mr. C. G. Renold. The list contains the names of twenty-five people who are actively associated with a wide range of commercial, industrial and educational establishments. It is emphasised, however, that these members of the Council have been appointed in their personal capacities and not as representatives of any organisation. In addition, various organisations are officially represented on the Council by Sir Norman Kipping, Federation of British Industries; Lord Dukes, Trades Union Congress; and Mr. J. I. C. Crombie, Civil Service. Sir Achibald McKinstry and Lieut.-Colonel L. Urwick will serve as Vice-Chairmen of the Council. The intention is that this Council shall act until the preliminary work of setting up the Institute has been completed, when it will be possible for the membership of the Institute to elect its own Council.

A Pressure and Suction Regulator

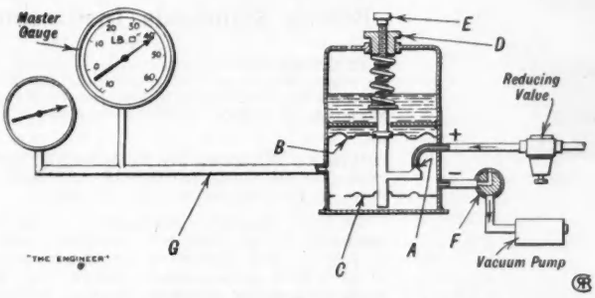
THE precision pressure and suction regulator shown in the accompanying illustration has been designed by Negretti and Zambra, 122, Regent Street, London, W.1, to facilitate the adjustment of air pressure to fine limits between 12 lb per square inch below and 65 lb per square inch above atmospheric pressure. It is particularly suitable for use in connection with the testing or calibration of indicating, recording and controlling instruments.

A rateless diaphragm of the firm's own design, which is embodied in the instrument,

PRESSURE AND SUCTION REGULATOR

makes the regulator very sensitive, and it is claimed to be adjustable to within 0·001in. of mercury. The change of regulated pressure is stated to be less than 1 per cent of any variation in the pressure of the air supply. In order to avoid the effects of considerable fluctuations in air supply, an ordinary pressure-reducing valve may be inserted in the air line before the regulator, if desired.

A restricted vent to atmosphere permits pressures to be reduced in the otherwise closed system, and obviates the possibility of any unintentional "build up" of pressure. This



DIAGRAMMATIC ARRANGEMENT OF REGULATOR

vent is controlled through a two-way cock, and is also used for linking up with a vacuum pump when exhausting is required.

When connected to instruments of average capacity, fine adjustment of the regulator rapidly produces the desired change of pressure. In order to effect rapid changes when used with apparatus of considerable volume, rough adjustment of pressure may be made by using a hand-operated valve by-passing the regulator and using the instrument only to effect the final close adjustments.

The diagram above shows the general arrangement of the mechanism of the instrument. The incoming air is controlled through a regulating valve A, the spindle of which is coupled to the derated diaphragm B at the top of the air chamber, and a spider valve C at the lower end. A heavy and a light spring couple the valve spindle to coarse and fine adjustment screws D and E at the top of the instrument. A volume of oil for diaphragm-damping purposes is contained in the upper half of the body. The vent pipe is coupled to a two-way cock F, which can be set open to the atmosphere or to connect the working chamber to a vacuum pump. The controlled pressure outlet pipe G is extended to connect a master gauge in parallel with the instruments being tested or calibrated.

A Heat-Resisting Glass

FOR many commercial and industrial purposes where high light intensities are needed, such as cinema projection, the heat which is inevitably associated with the production of light, causes great difficulties. It is therefore necessary to provide a means whereby this heat can be removed from the stream of radiation without reducing unduly the amount of light transmitted.

Any normal source emitting light emits at the same time a much greater proportion of its energy in the form of invisible radiation, which, while not contributing to the visual effect, is absorbed by and therefore heats up any body on which it falls. The light itself when absorbed gives rise to heating and there is therefore a natural limitation on the efficiency of a heat absorber of this type. A further requirement is that the glass which absorbs the invisible part of the spectrum shall not change the colour of the light to any appreciable extent. Any glass which absorbs heat must necessarily become hot, and glass on heating is liable to fracture. It becomes essential, therefore, that such a filter must have heat resisting properties as well as that in general it must be of low thermal expansion.

As the result of prolonged experimental investigation, Chance Brothers, Ltd., of Smethwick, has now produced on an unusual type of base, a glass which is claimed to combine the required properties to a remarkable degree. It is virtually colourless, *i.e.*, it does not absorb or change the colour of any light falling on it, and it absorbs almost completely all the invisible infra-red portions of the spectrum which cause heating, without any disadvantage as regards the visible portions. This glass is known as Chance ON19, and is available in the form of flat sheet of various thicknesses.

The physical properties of the glass are indicated in the table in the next column.

METHODS OF USING

Since ON19 glass has the property of almost complete absorption of the infra-red rays, it necessarily gets very hot in use, and in spite of its low expansion, serious strains can be set up, particularly when the radiation does not fall uniformly on the glass. In a projection system a heat absorbing filter must be placed somewhere between the lamp and the film. If placed close to the lamp it will get very hot and will need greater cooling than if at a greater distance from the lamp; on the other hand if it is closer to the film it is likely that the heat will be concentrated on the centre and the outer edges will be relatively cool, which again leads to breakage. Also, any minor defects in the glass, such as small bubbles, may appear on the projected picture if the glass is close to the film. The best place, therefore, is somewhere near the condenser lens and preferably on the lamp side of the condensers in order that the condensers themselves shall be subjected only to cool light. In this case, some form of forced cooling is probably necessary, but in such cases as those where forced cooling cannot be applied, the glass filter should be put on the inside of the condenser. In either case a small gap should be left between the glass and the condenser. It is frequently an advantage to cut the glass into strips so as to minimise stresses due to uneven heating, but in such cases care must be taken that the edges are smooth, and the glass must not be mounted so tightly that it is fractured from this cause.

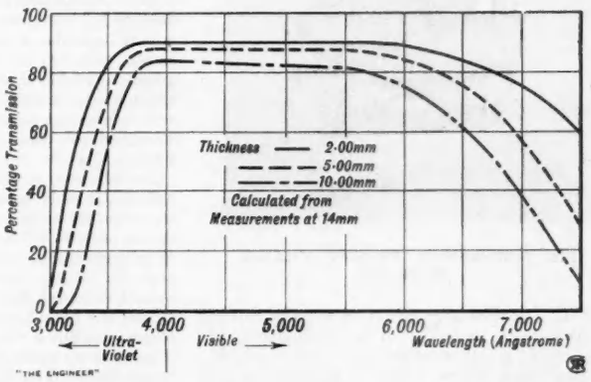
Owing to the particular and peculiar nature of ON19 glass, it is impossible for it to be moulded or provided in other shapes than the flat glass indicated above.

Light-Heat Transmission—Thickness Relation for (2848°K)

Thickness, mm.	Light, per cent	Heat, per cent
0·5	91·3	39·0
1·0	90·3	23·0
1·5	89·0	19·0
2·0	88·0	14·0
3·0	87·0	8·5
4·0	85·0	6·5
5·0	83·0	5·5
6·0	81·0	4·5

Refractive index	1·505
V-value	66·5
Specific gravity	2·5
Thermal expansion	59×10^{-7}
Annealing temperature ...	550° C.

Curves reproduced herewith indicate the percentage transmission over the range of wavelengths.



TRANSMISSION PROPERTIES OF CHANCE ON19 GLASS

IMPERIAL SHIPPING COMMITTEE.—It was recently announced by the Ministry of Transport that the Imperial Shipping Committee, whose activities were necessarily curtailed during the war years, is now taking steps to resume its work. The Committee has elected Sir Clement Jones, C.B., as its new Chairman, to replace Sir Frederick Leith-Ross, G.C.M.G., K.C.B., who resigned on taking up another appointment. Its immediate task is to make an inquiry into West Indian shipping services. An inquiry on this subject was started by the Committee in 1939, but was interrupted by the outbreak of war. The terms of reference of the new inquiry are:—"To survey the shipping needs of the British Colonies in the Caribbean area and Bermuda; to consider what shipping services will be required to meet the needs of the area in future, and to make recommendations how these services can be provided, taking into account air services existing or contemplated in the area." A substantial volume of evidence was collected before the war, but this is in many respects out of date, and fresh evidence will therefore be required. The Committee is ready to accept evidence from organisations or persons having an interest in West Indian shipping and trade, and such evidence should be sent, in writing in the first instance, to the Secretary, Imperial Shipping Committee, Berkeley Square House, London, W.1.

Two Special-Purpose Machines

Amongst the special machine tools which have recently been designed and built by Adcock and Shipley, Ltd., of Leicester, are a two-spindle keyway milling machine and a duplex centring machine.

The first of these machines, illustrated in

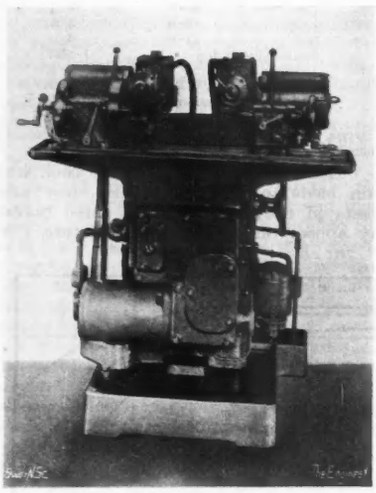


Fig. 1—Woodruff Keyway Milling Machine

Fig. 1, was specially designed for the milling of Woodruff keyseats in a crankshaft. It consists of a substantial base, containing the coolant tank, on to which is mounted a box cabinet. This cabinet carries a knee slide at the front and two cutter heads at the rear.

The work-holding fixture on the knee slide table comprises a simple indexing head for locating the work at one end, and a standard tailstock at the other. Components set in the fixture are fed upwards to the cutters by movement of the knee slide, which is power elevated by a cam driven through double worm and worm wheel reduction gear by an electric motor. The feed cam is laid out to give a quick elevation, a slow cutting feed and a rapid return cycle, at the end of which a limit switch stops the whole machine. The depth of keyway cut is controlled by the position of the knee elevating cam, which can be adjusted in a vertical plane by means of a hand wheel. A set of pick-off gears at the front of the knee can be changed to vary the time cycle of the machine.

Each of the cutter heads is powered by an independent motor, which drives the ball bearing mounted spindles through spiral cut gears. The heads can be adjusted longitudinally to alter the distance between the keyways being cut, from a minimum of 7in to a maximum of 17in. Each head incorporates means of transverse adjustment, so that one may be moved clear of the component while single keyways are being milled by its companion. A dead stop locates the heads in the forward position to set the keyway cutters centrally over the component.

During operation the machine is controlled by a conveniently situated lever on the knee, which is used to start and stop all the motors.

The duplex centring machine was originally designed for centring camshafts at each end, and is capable of accommodating many other classes of work. As can be seen from the photograph reproduced in Fig. 2, the cabinet bed of the machine carries a coolant and swarf tray, set underneath a box section bed, on which are mounted the centring heads and work-holding fixture.

For the centring operation two of the maker's automatic unit heads are used, and these move in suitable slides on the machine bed. The heads are fed by a rotating roller moving in a fixed cam track, which gives a rapid approach, slow drill feed, and rapid return of the drill spindles. Each head can be set independently by means of a hand wheel at the end of their slides, to allow for varying lengths of work. The working cycle is so arranged that each head stops independently at the end of its rapid return stroke.

The work-holding fixture, set between the heads and behind their slide, consists of an air-operated self-centring vice fitted with movable jaws. Shafts varying in diameter from $\frac{3}{4}$in to $1\frac{1}{4}$in can be held in the vice jaws, the distance between which can be altered from 3in to 16in for different lengths of work.

A single lever at the front of the machine opens the vice jaws when moved in one direction and closes the jaws and starts the working cycle when moved in the opposite direction.

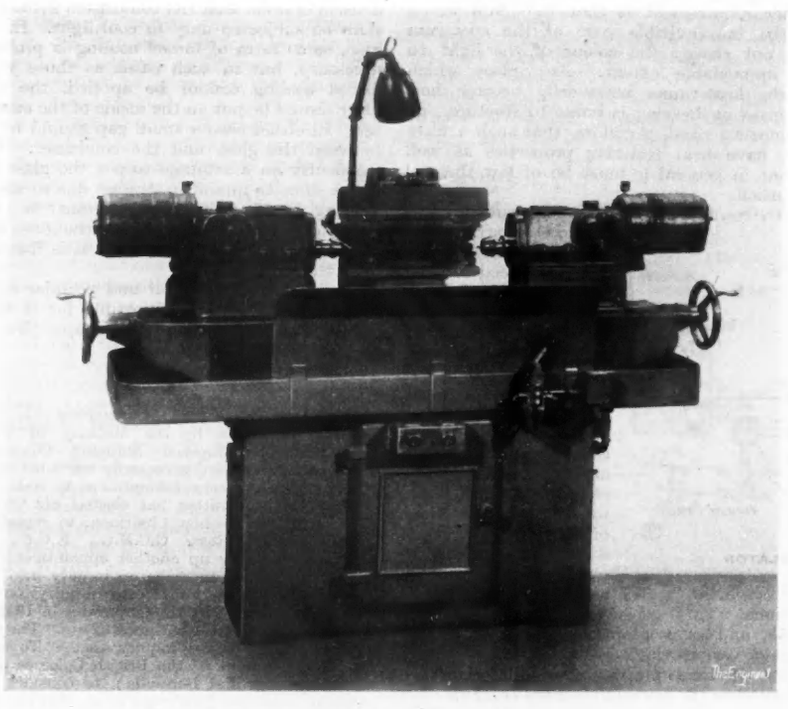


Fig. 2—Duplex Centring Machine

Chemicals from Petroleum

An announcement made by the Shell Petroleum Company, Ltd., foreshadows the establishment of a new and valuable industry in Great Britain: the production of chemicals from petroleum. The company's research staff has been working for many years to discover new uses for petroleum. The products which can be produced include a wide range of chemicals for use in industrial processes, *e.g.*, in the manufacture of paints, plastics, textiles, rubber, leather, and chemical and pharmaceutical preparations.

The new industry will provide training for a number of British scientists and technicians, working in conjunction with laboratories having the most modern equipment. The refining processes will be carried out in plants containing up-to-date equipment, much of which has never before been used in this country. A minimum of manpower will be required to carry out the processes, and the value of output per man will be among the highest in Britain's basic industries.

During recent years, the supply of coal by-products and those from fermentation processes has not been sufficient to fill the needs of home industry and the new source of supply will bridge the gap and provide a surplus for export. A feature claimed for the petroleum-derived chemicals is their very high degree of purity.

All the petroleum used as raw material will be imported from sterling sources. The company's productive capacity in the United Kingdom will be expanded to give a greatly increased output. An 85-acre site at Thornton-le-Moors, Cheshire, is being used for the erection of a new plant which will cost several million pounds, and will be ready for production next year. The output of this plant will mean a reduction in imports from America by 4,000,000 dollars a year. The present Shell refinery at Stanlow, on the Manchester Ship Canal, and that at Shell Haven, Essex, are being enlarged. The Stanlow refinery will double its present production of 24,000 tons a year of synthetic soaps, cleansing agents and wetting agents for industrial and domestic uses, and the Shell Haven plant, which produces insecticides, fungicides and other products will eventually produce 30,000 tons a year. An experimental farm of 170 acres at Woodstock, Kent, has been acquired for the study of plant life, pests and diseases, and improved methods of applying insecticides.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

GENERAL PURPOSE JOINTING MATERIALS FOR GAS-HEATED DOMESTIC APPLIANCES AND GAS INSTALLATION PIPES

No. 1337. The above specification has just been published. It provides for a resilient, general-purpose jointing material which is non-adherent to joint faces and re-usable. Tests for hardness, accelerated ageing, cracking, porosity, resistance to steam, swelling in benzole and resistance to acid are given.

HUMIDITY OF THE AIR (DEFINITIONS, FORMULÆ AND CONSTANTS)

No. 1339 : 1946. Owing to the many applications of hygrometric measurements, the same terms are often used to express different meanings, and various names are in use for many of these meanings or concepts. This British Standard has been issued in the hope that those concerned with hygrometry will adopt the terms and definitions recommended, which are based on majority usage. Simple formulæ are given for determining the vapour pressure, and indirectly the moisture content, absolute humidity, density, humid volume, and total heat of moist air, from wet and dry bulb temperature readings. Each formula is accompanied by a table of constants for various systems of units. Price 2s. post free.

American Engineering News

Freight Terminals for Road Haulage

A factor in the street traffic congestion in New York is constituted by the very heavy traffic of long-distance road haulage lorries and trucks to and from the West side of the city. To eliminate these trucks from the streets, the Port of New York Authority is building two large union or joint freight terminal stations, where outbound goods will be delivered by local trucks and assembled into full trucks for various destinations. For inbound goods, the trucks will be unloaded and goods sorted for collection or delivery throughout the city by the trucks of merchants or local truckers. The main building will be 1000ft long and 175ft wide, with a sorting or freight platform 800ft long and 80ft wide. This platform will have bays or tail-board spaces for 144 trucks, of which 80 will be for the long-distance trucks and 56 for local trucks of various owners and operators, leaving 8 for expansion of traffic. The terminal is so designed that all trucks loading and unloading will be entirely within the building, while in the present situation the streets are frequently obstructed by trucks backed up to the buildings and protruding into the street. An overhead dispatcher's gallery will extend the full length of the platform. For handling the freight with weights up to 10 tons, there will be an overhead travelling crane serving a transverse platform. Above the main floor will be two stories of offices for the Port Authority and for lease, together with toilet and rest rooms, restaurant, repair shop and other conveniences. Under the proposed plan of operation, the terminal will handle from 1600 to 2000 tons of freight daily. For that part of the Port lying west of the Hudson River, there will be a similar truck terminal, 1150ft long and 200ft wide. Its freight sorting platform will be 1000ft long and 100ft wide, accommodating 160 trucks, including 90 for the long-distance trucks, 60 for the trucks of local truckers, and private firms, with 10 bays for expansion. The freight-handling methods and machinery will be similar to those of the other terminal.

Irrigation in the United States

While irrigation is the main objective of the U.S. Bureau of Reclamation, it has supplemental work in the control of water for flood control, river regulation, hydro-electric development and improvement of navigation. It serves 8000 square miles of arid and semi-arid lands in seventeen of the Western States, about half of this land having no other water, while the rest has supplies insufficient for agricultural needs. In its 44 years of service it has constructed 100 storage dams and 68 diversion dams, of concrete, masonry, earth embankment and loose-rock embankment. The concrete dams include gravity, arch, multiple arch and hollow types. For the distribution of the water it has built 335 pumping plants, 15,325 miles of canals, 107 miles of tunnels, and a great number of levees, dikes, bridges, culverts, flumes and other structures. In addition, it had, in 1946, hydro-electric power plants at thirty-two of the dams, with an aggregate capacity of 2,500,000 kW, while current was distributed by 2516 miles of transmission lines. The total value of crops on 6600 square miles thus irrigated in 1946 was £109,000,000, or £26 per acre, except that in orchard districts it was much higher, reaching £213 per acre on one of the orchard regions in the State of Washington. The relation of irrigation to farming is indicated by the Weber River project in Utah, whose normal income had been under £500,000, but which reached when irrigated £3,400,000. A large project now in its early stages, is for development in the Missouri River basin, which will require some 150 separate works for dams, power plants, distributing works, and other facilities, of which thirty are already authorised. This unruly river, whose basin or watershed, with its tributaries, includes parts of nine States, will be regulated also for flood control and navigation, where without control it has caused widespread flood damage, with loss of life, destruction of property, and erosion of great areas of land. The Bureau had £50,000,000 for expenditure in 1947, but has had to limit its programme under Government orders to halt work not connected with the housing problem. However, this does not affect work already under way, which includes eight large dams.

Pumping Sands and Slurries

A review of American practice in the pumping of sands, slurries and slimes points out that within the normal operating limits of a pumping system the friction factor will decrease with increase in velocity. When this velocity in a pipe line is insufficient to keep the solids in suspension, the total friction head is greater than when the velocity is higher, but the system can usually be put in balance by a slight increase in the volume of feed to the pump and in the speed of the pump. The velocity must be in excess of the critical velocity of the mixture, which is that which will move the fluid mixture without any solids settling out. It may vary from 3ft per second for slimes to 18ft per second for sand and gravel in dredging, depending upon the screen analysis, concentration and specific gravity of the solids. In general, the volume should be held constant, so as to maintain the required velocity. This is often accomplished by means of a sump of sufficient capacity to take care of slight surges in the volume, but it should not be so large as to become a settling chamber. A fresh-water, float-controlled make-up valve will ensure a constant volume. Mill-waste water may be used for this purpose. If the quantity of fluid will vary within certain limits, the pipe-line should be large enough to permit the velocity at the lowest limit to be maintained above the critical point. Under such conditions, the pump speed must be adjusted to meet the volume condition as it changes. For pumping frothy mixtures, the surface of the liquid should be at least 6ft above the centre line of the pump suction. Pumps handling materials are not as efficient as clear-water pumps, owing to the inevitable abrasion. They are almost always of the single-stage, centrifugal type, and for high heads it may be necessary to use two or more pumps of moderate speed in series rather than one pump at excessive speed. For any particular installation, the pumps and sump design must be adjusted to the local conditions, total dynamic heads must be figured accurately, and operative and maintenance procedures must be adopted and adhered to. The concentration of solids at a given plant will usually be controlled by the many steps followed in a flow sheet.

American Copper Mine and Smelter

The great copper mine at Morenci, in Arizona, has an estimated ore volume of 230 million tons of ore, averaging 1·15 per cent of copper. The plant was designed to handle 25,000 tons of ore daily, but for two years of the recent war the U.S. Government financed an additional capacity of 20,000 tons. It is an open-cut mine, and up to July, 1946, the excavation aggregated nearly 200 million tons, including 43 million tons of ore. The ore body is exposed for some 5000ft on each of ten benches 50ft wide. There are 50 miles of railway track and both ore and waste are handled by 250 steel side-dump railway wagons. Loading is done by a score of oil-electric cranes with 5-yard buckets, and the trains are handled by sixteen electric locomotives of the combination trolley-battery type, supplemented by a dozen oil-electric locomotives. The mill has a capacity of 45,000 to 50,000 tons per day, and from 43 million tons of ore it has produced 1,643,000 tons of concentrate yielding 393,000 tons of copper. The ore is ground to pass a 200-mesh screen. Primary grinding in twenty-seven ball mills is followed by regrinding in six ball mills, so that 65 per cent will pass a 325-mesh sieve. About 93 per cent of the copper is recovered. Concentrate is carried from the mill to the smelter by two conveyor belts, 1000ft long, and is fed, without roasting, to reverberatory furnaces fired by natural gas. Dust is recovered by collectors. Of four reverberatory furnaces, 25ft by 105ft, three are normally in operation; and of six converters, 13ft by 25ft, four are normally in operation. The furnaces handle 545 tons of dry charge per day and produce a matte which averages 34·34 per cent copper. For a 50,000-kW power plant 40 per cent is provided by waste heat from the reverberatories. At this smelter is the highest chimney in the world, 612ft, with a diameter of 40ft at the bottom and 24ft at the top.

American Oil-Electric Locomotives

The great coal strike in the United States where the head of the miners' union defied the Government and caused nation-wide distress and confusion, led to increased interest being taken by the railways in locomotives of the oil-electric type. One railway has put in operation a triple-unit machine of 6000 h.p., designed for general passenger and freight train service at 75 miles an hour, or fast passenger service at 102 miles an hour. Its framing and enclosure are largely welded, and each unit is mounted on a pair of six-wheeled bogies, with motors geared to the two outer axles, which have 40in rolled steel wheels. Each unit has a ten-cylinder 2000 h.p., two-stroke oil engine, with two opposed pistons in each cylinder. The cylinders are 8½in by 20in, equivalent to 20 cylinders of 10in stroke. For the single-geared arrangement, the gear ratio is 63-24. Curves of 275ft radius can be negotiated. The traction motors are direct-current, series-wound, commutating pole machines. The regulating system is of the electric-hydraulic type. Auxiliaries are electrically driven, and there are three steam generating sets. Current at 600 volts is delivered to the traction motors. General dimensions and features are as follows:—

Total weight in service	500 tons
Weight on driving axles—12	350 tons
Weight on idler axles—6	150 tons
Length overall	195ft
Bogie centres spacing, each unit ...	36ft
Bogie wheelbase	16ft
Tractive force, continuous	83,000 lb
Tractive force, maximum, at starting	165,400 lb
Journals	6½ by 12in
Fuel oil, each unit	1,600 gallons
Lubricating oil, each unit	240 gallons
Cooling water, each unit	490 gallons
Sand, total	114 cubic feet

Rotary Furnaces for Rubbish

Disposal of garbage and combustible rubbish is a vexing problem in most large American cities, where the two classes of refuse are sometimes handled together and sometimes separately. One of the latest developments is at the city of Los Angeles, which has put into operation a battery of revolving kiln furnaces for combustible matter. This city separates its refuse into food wastes, which goes to a hog farm as feed; non-combustible rubbish, which is sorted over to salvage bottles and scrap metal; and combustible rubbish, which now goes to the kiln furnaces. Combustible rubbish is delivered at the disposal plant by motor lorries and discharged into a concrete pit of 300 tons capacity, with tailboard capacity for sixteen lorries. Travelling cranes with 2-yard grab buckets feed the contents of the pit to two bins or hoppers, each of which has a hydraulic ram of 8ft stroke, feeding a shredding machine through an opening 5ft wide and 2ft high. Each shredder is driven by an electric motor of 150 h.p. and is of the hammer-mill type, with loose blades on four shafts running at 1200 r.p.m. The shredded product, in pieces averaging the size of a walnut, is fed by a drag conveyor to hydraulic rams which in turn deliver it into the upper ends of the inclined kiln furnaces. Each kiln is 32ft long, inclined at 15 deg. and having a diameter of 11ft at the upper or receiving end and 7ft at the lower or discharging end. It is lined with refractory brick. The speed is one revolution in five to fourteen minutes. Gases pass through combustion chambers into spray or cooling chambers, where light ash is removed. The burned product falls by gravity into a quenching trough, from which it is removed by conveyors to a drainage and storage pit. Each furnace can handle 5 tons per hour. The entire plant will be handled by a superintendent with six men.

Industrial and Labour Notes

Five-Day Week in the Mines

A delegate conference of the National Union of Mineworkers held in London, on Friday last, March 14th, expressed its approval of an agreement made between the union and the National Coal Board for a five-day week in the coal-mining industry. The agreement, which is to operate from the first Monday in May, provides that underground workers shall work five consecutive shifts of seven and a half hours, plus winding time. Those employed at the surface are to work a five-day week of 42½ hours.

For working five consecutive shifts a week, day workers will receive a sixth day's pay as bonus, and for piece-workers the bonus is to be sixteen per cent of their earnings. The cost of the five-day week, according to Mr. W. Lawther, President of the union, is estimated at £24,000,000 a year. Other concessions to the miners include payment of time and a half instead of time and a third for overtime, with double time for Sunday work; six paid statutory holidays annually; free bath facilities; and an increase from one penny to twopence a ton in the levy for miners' welfare.

Furthermore, it is understood that the union will give every encouragement in the matter of recruitment to the mines, and will not oppose up-grading and transfer of miners to other pits or areas where this may be necessary to increase production. Nor will objection be raised against employing displaced persons in suitable cases, if they speak English, join the union, work for the union rate, and do not displace British miners.

Staggering of Hours

The Ministry of Labour's Joint Consultative Committee, on which the British Employers' Confederation and the Trades Union Congress are represented, held another meeting on Thursday of last week to consider industrial problems arising from the shortage of electrical generating plant. Reports received from the Regional Boards for Industry showed that substantial progress had been made in the consideration of the adjustment of working hours. Various arrangements had been made or proposed which would greatly assist in meeting the difficulties experienced or anticipated. Both sides of industry, it was stated, had shown a ready desire to co-operate, and the Minister of Labour, who presided over the committee, paid tribute to the valuable work being done both by the Regional Boards for industry and their district committees.

It was felt, however, that the problem of staggering hours differed according to the season and the industries involved, and it was, therefore, decided to set up, under the chairmanship of an officer of the Ministry of Labour, a sub-committee of the Joint Consultative Committee, to keep the problem under continuous review. The sub-committee will consist of representatives of the Government departments mainly concerned, the Central Electricity Board, the British Employers' Confederation, and the Trades Union Congress. In particular, its function will be to make available to both sides of industry all the necessary relevant facts to enable decisions to be taken as to the most appropriate steps for adjusting hours of work.

The Factories Acts and Staggered Hours

According to the Trades Union Congress, modifications of the Factories Acts, which could necessarily arise out of the staggering of working hours are receiving consideration by the Ministry of Labour's Joint Consultative Committee. These modifications relate to night work; work on Saturday afternoon or on Sunday; day work starting before 7 a.m. or finishing after 8 p.m.; dividing workers in one factory into two shifts or sets with different working hours, so that the finishing time for the second set is more than eleven hours after the starting time for the first set; and different meal times for different sets.

The suggestion is that, for the time being, the matter should be dealt with by emergency orders similar to those which applied during the two great wars. One or more Orders, it is considered, might meet the situation, if they were of the same nature as the "general orders" made in the recent war, but without requiring special permission from the factory inspector in each case, except, possibly, for night work schemes. It is explained by the T.U.C. that almost any scheme for shift work or staggering of working hours involves modifications of the Factories Acts where women or young workers are concerned, but it cannot yet be foreseen exactly what modifications may be needed in different cases.

The proposal is, therefore, for an immediate experimental Emergency Order, which could be reviewed in a few weeks' time to see what alterations might be necessary. Schemes started without taking into account the existing requirements of the Factories Acts would probably create breaches of the law. It is to facilitate emergency arrangements now being made regarding working hours that the new Order is proposed.

The Status of Industry

Amongst the papers presented at the recent Productive Efficiency Conference at Wolverhampton, organised by the Institution of Production Engineers, was one by Mr. W. C. Puckey, on management problems. One of the problems dealt with in the paper related to the "status" of industry, and two of the questions posed by Mr. Puckey were "What makes men strike?" and "Why do the great majority of strikes occur among manual workers of the semi to skilled grades?" He believed that it was largely owing to an inferiority complex or a lack of status recognition.

The trend of the industrial revolution, Mr. Puckey said, had relatively debased the craftsman in society, and to be in industry at all had meant that you were not really in the "top drawer." He urged that a more positive attempt should be made to raise the present lower status of the industrial manual worker. An analysis showed that less than one-third of the total working population were what Mr. Puckey described as direct workers, and they were the people we thought about when we talked of increasing production. Unless their status was increased, they would get less and less numerically, and it would become impossible to improve their rate of output in order to maintain, let alone increase, our standard of living.

Iron and Steel Production

The iron and steel production figures of the United Kingdom for February show that there was a considerable decline compared with the corresponding month of 1946, a decline which is attributable mainly to restricted fuel supplies. The output of pig iron averaged 126,200 tons a week in February, or an annual rate of 6,560,000 tons. In January, production was at an annual rate of 7,806,000 tons, and in February, 1946, the annual rate was 7,599,000 tons. The production of steel ingots and castings in February was 206,300 tons a week, corresponding to an annual rate of 10,726,000 tons. The annual production rate in January was 12,470,000 tons, and in February, 1946, 12,854,000 tons.

In announcing these figures, the British Iron and Steel Federation explains that production cannot be expected to improve unless fuel supplies, particularly of coking coal, are increased. The importance of coking coal arises not only from the direct connection between coke supply and pig iron production, but also from the need to maintain a proper gas balance in integrated works. Shortage of coking coal therefore leads not only to reduced supplies of pig iron but also to lack of gas for steel furnaces.

On Monday, last, it was announced that an agreement has been reached between the Iron and Steel Trades Employers' Association and the Iron and Steel Trades Confederation, under which melting furnaces in the heavy steel trade will operate continuously throughout the week-end on the basis of a forty-eight-hour week. Provision has also been made for those plants where furnaces are not yet able to operate fully throughout the week to work extra week-end shifts. This closes the gap that has hitherto existed when steel furnaces were damped down from Saturday, 1 p.m., until Sunday, 2 p.m. It is estimated that the effect of the new agreement on output will be that an additional 750,000 tons will be produced per annum from the existing furnaces, and when all plants are able to complete arrangements to operate fully under the new scheme, the additional output of steel ingots should be in excess of 1,000,000 tons per year.

There can be no doubt that the additional output obtaining under the new scheme will be a substantial contribution to the national recovery, but the full value of the agreement in terms of steel output cannot be obtained unless adequate supplies of coal and transport facilities are made available to the industry.

The Industrial Organisation Bill

The London Chamber of Commerce has recently prepared a memorandum setting out its views on the Industrial Organisation Bill and comments on the Development Councils, proposed by the Bill, to increase the efficiency and productivity of various industries "to enable them to render better and more economical service to the community."

The Chamber says that without compulsory powers it is not at all evident why a Development Council is thought to be more likely to bring about arrangements for "co-operative organisations for supplying materials and equipment, for co-ordinating production, and for marketing products" than existing trade associations. It may be said, the memorandum continues, that these Development Councils will not themselves have any knowledge of any of the matters with which they are to deal, but will rely solely upon paid experts.

In the Chamber's submission, the imposition on an industry of a body, the majority of whose members would presumably have had no experience of directing and managing that particular industry, is likely to increase the sense of exasperation and frustration in the management of business which is one of the most serious features of our time. The memorandum expresses the view that it is time to call a halt to the multiplication of schemes intended to enable people the better to go about their daily work, so that a reasonable time may be left or the actual business of doing the work. Over-organisation, the memorandum concludes, can be, under present conditions, a great menace to the industrial recovery of this country.

The F.B.I. Southern Regional Council

The Federation of British Industries has recently formed a Southern Regional Council and at its first meeting at Reading, under the chairmanship of Captain G. E. T. Eyston, a director of John I. Thornycroft and Co., Ltd., Sir Norman Kipping, Director-General of the F.B.I., spoke on the work and aims of the Federation. The new Council is strongly representative of local and regional industries, and includes among its seventeen members leading industrialists from the main centres of industry in the region. The Council will ensure close contact between regional members and the Federation's headquarters, and it will take a definite part in the formulation of F.B.I. policy.

French Engineering News

(From our French Correspondent)

PARIS, Mar. 14th,

A vast programme for petrol research costing 40 milliard francs and lasting over fifteen years has been announced for the Colonies. In North Africa 130,000 square kilometres will be prospected and bored. A further 60,000 square kilometres will be geologically and geophysically prospected. Boring will take place to a total of 360,000 m, at a cost of 6 milliard francs, and lasting six years. At a later stage 190,000 m will be bored, at a cost of 3 milliards, to take three years.

In French East Africa it is proposed that 50,000 square kilometres at Gabon should be prospected and bored, and that 60,000 square kilometres be prospected at Madagascar, Cameroons and New Caledonia. At the end of ten years one-third of the suitable ground in the French Union will have been prospected. In France most urgent work will be the prospection and boring of 60,000 square kilometres, and later a further 100,000 square kilometres will undergo geological and geophysical work. This will take place mainly in the south, and will cost 2 milliard 600 million francs over a period of four years.

* * *

Access to the port of Dunkirk by night is now possible, following the setting up of lighted buoys. Work now going on at the port makes it likely that shipping with a draught of 5 m will shortly be able to enter the Guillain lock.

At Boulogne the wet dock is ready to be installed, but as no floating crane is available it will be necessary for one to be brought from Dunkirk. The work is expected to be completed within a month.

Engineers are still at work trying to refloat the "Liberté," but are not optimistic about saving the ship. At the moment they are trying to seal all the openings, divers' descents are being planned, and machinery prepared before pumps are installed. Divers are ready and considerable material, including floats, pumps, &c., are at hand to attempt to refloat the vessel.

Internal shipping now has excellent facilities at Rouen. The river port offers a transit depot for merchandise, and convoys for Paris can be re-formed there. The Seine will take convoys of eight or ten boats, which effects considerable economy in traction. A programme for improving navigability of the Seine, which is broken upstream by islets and secondary channels, has been studied, and work will begin as soon as conditions permit. At the same time, the decision to raise the height of the Rouen bridges to 7 m will permit the superstructure of boats circulating between Rouen and Paris to be increased.

The St. Malo basins have been drained following the completion of the work on the temporary lock, whose downstream gate now has to be installed. The repairing of the breach in the quay will permit the water depth to be maintained at 7·5 m.

The plan for the reconstruction of Saint-Nazaire includes a modern fishing centre served by a railway and accessible to lorries.

* * *

At a time when France is in desperate need of coal it is being asked why the Lyons basin is not being exploited. Here there are apparently coal seams, 6 m to 9 m deep, and extending over large areas. It is also being complained that French effort is almost entirely expended on working existing main seams, giving good-quality coal. New mines are not opened up and the rational use of inferior coal is not developed, although it is easy to extract and could be gasified on the spot. By exploiting 50 or 60 million tons of this lignite and poor-quality coal a year sufficient gas could be produced to satisfy the industrial and domestic needs of the country. This gas could be piped long distances by a grid, as is done for electricity. In addition, important by-products, such as sulphur and ammonia products, would be available.

Notes and Memoranda

Rail and Road

RAIL IMPROVEMENTS IN NORTH WALES.—To deal with the increased traffic arising from the opening of a new holiday camp at Penychain (Caernarvonshire), the London, Midland and Scottish and Great Western railways are carrying out improvements, which are expected to be completed by Easter, on their branch lines serving the district. On the L.M.S. the improvements will include lengthening the crossing loops at Dinas Junction, Brynkir and Llangybi, and signalling alterations at these three places, and also at Groeslon and Penygroes. The effect will be to enable ten-coach trains to be worked over the 18¾ miles heavily graded, single line branch between Caernarvon and Afon Wen. The G.W.R. is doubling a mile of track between Afon Wen and Penychain, providing a new "down" platform and extending the existing platform on the "up" side at Penychain Halt, which will be renamed "Penychain—for Pwllheli Holiday Camp."

LONDON TRANSPORT AND STAGGERED HOURS.—Two new London Transport posters show in graphic contrast how homeward traffic in the London area is now concentrated in the hour from 5 to 6 p.m. In the spaces on the first graph representing this period the symbols for passengers are bunched together, expressing the overcrowding of transport vehicles that takes place. It is shown that over 130,000 people go home in a single half hour. By contrast, the second diagram shows how greater comfort would be obtained by staggering working hours. In this the effects of even loading from 4.30 to 6.30 p.m. are shown, and it is shown that, under staggering, passengers would go home in eight half-hour periods in each of which 97,000 people would travel. Ten of the fourteen local stagger zones of Central London have now completed the collection of detailed statistics of when workers begin and finish work in their areas. Hundreds of firms have collaborated in supplying particulars of hours of work of their staffs.

Air and Water

G.W.R. CROSS-CHANNEL VESSELS.—The two new 3000-ton cross-channel ships now being built at Birkenhead for the Great Western Railway are to be named "St. David" and "St. Patrick" after the vessels they are replacing, which were lost on war service. The "St. David" was launched on February 6th, and the "St. Patrick" is expected to be launched in April. Both vessels will accommodate 1300 passengers, 50 motor-cars and 350 tons of freight, while sleeping quarters for 400 will be provided by single, double or open berths and luxury cabins. All modern aids to navigation are being incorporated, including radar and echo sounding equipment. Another G.W.R. ship, the s.s. "Great Western," until recently employed on the Fishguard-Waterford service, is being converted to oil burning. The accommodation for passengers and crew is being extended, re-arranged and generally improved.

I.N.A. SPRING MEETING.—The spring meeting of the Institution of Naval Architects will be held at the Royal United Services Institution, Whitehall, S.W.1, on Wednesday, Thursday and Friday next, March 26th, 27th and 28th. The meeting will begin at 10.15 a.m. on Wednesday, and after the formal business Admiral of the Fleet Lord Chatfield will deliver his Presidential Address. The following papers will then be presented:—"Improved Arrangements of Accommodation for Modern Cargo Vessels," by Mr. J. E. Church; and "British Submarine Design During the War," by Mr. A. J. Sims. The annual dinner of the Institution will take place at the Connaught Rooms, Great Queen Street, W.C.2, on Wednesday evening, at 7.15 p.m., when the Right Hon. Winston Churchill, O.M., C.H., M.P., will be presented with his Diploma of Honorary Membership. On Thursday, the meeting will resume at 10.15 a.m., when the following papers will be discussed:—"Classification Standards and Longitudinal Strength," by Mr. J. L. Adam; and "Limits of Torsional Vibration Stress in Marine Oil Engine Shafting," by Dr. S. F. Dorey. At 2.30 p.m. papers on "Corvettes and Frigates," by Mr. A. W. Watson; and "Coastal Force Design," by Mr. W. J. Holt, will be read; and at 5.15 p.m. the two following papers will be taken:—"Notes on the Development of Landing Craft," by Mr. R. Baker; and "Notes on Depot and Repair Ships," by Mr. H. E. Skinner. On Friday morning, at 10.15 a.m., papers will be presented on "Residuary Stability," by Professor C. W. Prohaska; and "Strain and Breakage Recording on H.M.S. 'Vanguard' During Launching," by Mr. D. M. Baker.

Miscellanea

THE FERRANTIANS.—The fourth reunion dinner of past and present Ferrantians was held at the Savoy Hotel, London, on March 11th, when Mr. V. Z. de Ferranti was the guest of honour. Mr. A. E. Hadley presided.

THE LATE MR. W. R. HOLLAND.—We record with regret the death, on March 10th, of Mr. William R. Holland, of the A.C. Engineering Department of the British Thomson-Houston Company, Ltd., Rugby. He had been in the service of the company since 1916.

INSTITUTION OF CHEMICAL ENGINEERS.—The twenty-fifth annual corporate meeting of the Institution of Chemical Engineers will be held at the Connaught Rooms, Great Queen Street, London, W.C.2, on Thursday, April 10th, at 11 a.m. Mr. Hugh Griffiths will deliver his Presidential Address on "Crystallisation" at 12 noon, and the annual luncheon will follow at 1 p.m.

EXPERIMENTAL STRESS ANALYSIS.—The recently formed Experimental Stress Analysis Group will hold its first conference at University College, London, on Tuesday, Wednesday and Thursday next, March 25th–27th. The programme includes an opening address by Professor J. F. Baker, of the University of Cambridge, on "Experimental Stress Analysis," and discussions on brittle lacquers, photo-elasticity and electric strain gauges.

CHEMICAL ENGINEERING DESIGN.—The North-Western Branch of the Institution of Chemical Engineers proposes to hold a refresher course of about three days' duration at Manchester, in September next. The course will take the form of the design of a plant to manufacture mononitrotoluene. Mr. M. B. Donald will act as co-ordinator and will be assisted by Mr. C. H. Bowden, Mr. J. M. Coulson, Mr. F. Rumford and Mr. F. E. Warner, who will deal with process information, physical design, flow sheets and mechanical design. The course will be residential as well as non-residential and is open to all engaged in the chemical industry. The number of places will be limited and provisional application should be made now to Dr. J. S. Hunter, "Melrose," 22, The Crescent, Northwich, Cheshire.

S.I.M.A. BOWEN TRUST.—The Scientific Instrument Manufacturers' Association of Great Britain, Ltd., has had presented to it by Mr. W. Bowen a substantial capital sum, the income of which is to be devoted to the encouragement and development of invention, design, research processes and manufacturing technique in the scientific instrument making industry. For the current year it has been decided to award five prizes, totalling approximately £125, for the five best papers on a new invention; an improvement in design; an improvement in manufacturing technique; a new development or process arising from research affecting or relating to a scientific instrument. Candidates for the competition must be employed by a firm which is a member of S.I.M.A., and papers must be submitted by April 30th. Full particulars of the competition may be obtained from the Secretaries of S.I.M.A., Messrs. Binder, Hamlyn and Co., River Plate House, 12–13, South Place, London, E.C.2.

GENERATION OF ELECTRICITY, FEBRUARY, 1947.—The effect of the recent restrictions in the consumption of electricity by industrial and domestic users is reflected in a recent statement by the Electricity Commissioners containing figures for the quantity of electricity generated and sent out by authorised undertakers. It is interesting to observe that, in spite of these restrictions, the generation of electricity in February, 1947, was substantially greater than in the corresponding month of 1946. Thus, 3680 million units were generated by authorised undertakers in Great Britain during February, 1947, as compared with the revised figure of 3462 million units during February, 1946, an increase of 218 million units, or 6·3 per cent. The number of units sent out from the generating stations of the authorised undertakers (*i.e.*, units generated less units consumed in the stations by auxiliary plant, &c.) was 3474 million units in February, 1947, which represents an increase of 202 million units, or 6·2 per cent over the revised figure of 3272 million units in February, 1946. During the first two months of 1947 ended February 28th, the authorised undertakers generated 8351 million units, representing an increase of 747 million units, or 9·8 per cent above the revised figure of 7604 million units for the corresponding period of 1946. During these two periods the total numbers of units sent out were 7898 million units and 7189 million units respectively, representing an increase of 709 million units, or 9·9 per cent.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, April 15th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Light and Colour as Applied to Works Equipment," W. Robinson. 6.15 p.m.

Institute of Marine Engineers

Tuesday, March 25th.—85, The Minories, E.C.3. "Dryness of Steam and Priming in Marine Boilers," Com. (E) L. Baker, R.N. 5.30 p.m.

Friday, March 28th.—85, The Minories, E.C.3. Annual general meeting. 5.30 p.m.

Institute of Road Transport Engineers, Ltd.

Wednesday, March 26th.—MIDLANDS CENTRE: Chamber of Commerce, New Street, Birmingham. "Paints for Road Transport," A. E. Thursby. 7 p.m

Institute of Welding

To-day, March 21st.—S. LONDON BRANCH: Technical Institute, Gravesend. "Detailed Design of Arc Welded Components," M. Riley. 7.30 p.m.

Institution of Chemical Engineers

Saturday, March 22nd.—N. WESTERN BRANCH: College of Technology, Manchester. "Purification and Azeotropic Dehydration of Acetonitrile," H. R. C. Pratt. 3 p.m.

Institution of Civil Engineers

To-day, March 21st.—BIRMINGHAM ASSOCIATION: Queen's Hotel, Birmingham. Annual Dinner. 6.30 p.m.

Tuesday, March 25th.—Great George Street, S.W.1. "The Problem of Coast Erosion," Jack Duvivier. 5.30 p.m.

Thursday, March 27th.—BIRMINGHAM ASSOC.: Loughborough College, Loughborough. "The Severn Barrage Scheme," J. Allen.

Friday, March 28th.—YORKSHIRE ASSOC.: Great Northern Station Hotel, Leeds. "Reinforced Concrete Chimney and Offices at the Valley Power Station of the Bradford Corporation," T. H. Carr. 7 p.m.

Institution of Electrical Engineers

Saturday, March 22nd.—N. MIDLAND STUDENTS: Corporation Electricity Department, Whitehall Road, Leeds. "The Place of the Engineer in the Post-War World," Sir Arthur P. M. Fleming. 2.30 p.m.

Tuesday, March 25th.—SCOTTISH CENTRE: Royal Technical College, George Street, Glasgow. "The Development and Design of Colonial Telecommunication Systems and Plant" and "The General Planning and Organisation of Colonial Telecommunication Systems," C. Lawton and V. H. Winson. 6.15 p.m.

Tuesday, April 15th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Does Standardisation Conflict with Progress?" 5.30 p.m.

Institution of Factory Managers

Wednesday, April 16th.—S.E. LONDON BRANCH: Bonnington Hotel, Southampton Row, W.C.1. "Education for Management," Colonel L. Urwick. 6.45 p.m.

Institution of Mechanical Engineers

To-day, March 21st.—Storey's Gate, St. James's Park, S.W.1. "The Combination Torque-Converter and Fluid-Coupling Drive," B. J. Tams and A. L. Gatiss. 5.30 p.m.

Saturday, March 22nd.—GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1. Exhibition of Cinematograph Films. 3 p.m.

Monday, March 24th.—GRADUATES' SECTION: Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Three papers on "Hydro-Electric Power Schemes." 7 p.m. (Joint meeting.)

Friday, March 28th.—Storey's Gate, St. James's Park, S.W.1. "The Norwich Heat Pump," J. A. Sumner, and "The Air Cycle Heat Pump," T. F. T. Thomas. 5 p.m.

Institution of Municipal Engineers

Monday, March 31st.—W. MIDLAND CENTRE: James Watt Institute, Birmingham. "The Birmingham Water Scheme." C. A. Rishbridger. 6 p.m. (Joint meeting).

Institution of Production Engineers

Thursday, March 27th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Precision Thread Rolling," W. A. Hawkins. 6.30 p.m.

Saturday, March 29th.—YORKSHIRE GRADUATES: Great Northern Hotel, Leeds. "The Application of Electricity for Production," E. C. Walton. 2.30 p.m.

Wednesday, April 9th.—LUTON SECTION: Central Library, Luton. "Shot Peening," W. Neville. 7 p.m.

Thursday, April 10th.—WOLVERHAMPTON SECTION: Station Hotel, Dudley. "Gear Manufacture and Inspection," F. J. Everest. 7 p.m.

Institution of Structural Engineers

Thursday, March 27th.—11, Upper Belgrave Street, S.W.1. "Stress Distribution in Steel Portal Frame Knees," A. W. Hendry. 6 p.m.

Junior Institution of Engineers

To-day, March 21st.—39, Victoria Street, S.W.1. Discussion: "Furnace Practice." 6.30 p.m.

Monday, March 24th.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. Presidential Address: "The Spotlight on Production," A. Roebuck. 7 p.m.

Wednesday, March 26th.—N. WESTERN SECTION: Engineers' Club, Albert Square, Manchester. Presidential Address: "Inspection," A. W. Sproull. 7 p.m.

Friday, March 28th.—39, Victoria Street, S.W.1. "An Engineer Visits Sweden," Hubert J. N. Riddle. 6.15 p.m.

Wednesday, April 2nd.—MIDLAND SECTION: James Watt Institute, York House, Great Charles Street, Birmingham. "Some Aspects of the Physics and Testing of Electrical Sheet Steels," N. F. Astbury. 6.30 p.m.

Friday, April 11th.—39, Victoria Street, S.W.1. "Prestressed Reinforced Concrete," C. E. Reynolds. 6.30 p.m.—WESTERN MEMBERS: Merchant Venturers' Technical College, Unity Street, Bristol. Films, "Valley of the Tennessee," "The Town To-day and To-morrow." 7 p.m.

London Association of Engineers

Saturday, April 5th.—Charing Cross Hotel, W.C.2. "Photography in Engineering," G. B. Macalpine. 6.30 p.m.

Manchester Association of Engineers

To-day, March 21st.—Engineers' Club, Albert Square, Manchester. Annual general meeting. 6.30 p.m.

Manchester Geological and Mining Society

Tuesday, April 15th.—Engineers' Club, Albert Square, Manchester. "Belt Conveyors," J. H. Plumtre. 3.15 p.m.

Manchester Statistical Society

To-day, March 21st.—Society of Architects, 16, St. Mary's Parsonage, Manchester. "Analysis of Variance," L. H. C. Tippett. 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Wednesday, March 26th.—STUDENTS' SECTION: Bolbec Hall, Newcastle-on-Tyne. "Combustion in the Internal Combustion Engine," H. W. McCabe. 6.45 p.m.

Friday, March 28th.—Mining Institute, Newcastle-on-Tyne. "Some Gear-Cutting Inaccuracies and their Effect on Gear Loads and Gear Noises," S. F. Dorey and G. H. Forsyth. 6 p.m.

Monday, March 31st.—TEES-SIDE BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough. "The War Effort and Organisation of British Ship Repairing, 1939–45," Sir Lawrie Edwards. 6 p.m.

Royal Aeronautical Society

Thursday, March 27th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The War in the Ether," Air Vice-Marshal E. B. Addison. 6 p.m.

Thursday, April 10th.—Inst. of Civil Engineers, Great George Street, S.W.1. "A Review of Production Difficulties in Relation to Aircraft Design," C. E. Fielding. 6 p.m.

Thursday, April 17th.—Inst. of Civil Engineers, Great George Street, S.W.1. "Testing Civil Aircraft," P. A. Hufton. 6.30 p.m.

Royal Institution of Chartered Surveyors

Monday, March 31st.—12, Great George Street, S.W.1. "Valuation Problems Affecting Licensed Property," S. Motion. 5.30 p.m.

Royal Institution of Great Britain

To-day, March 21st.—21, Albemarle Street, W.1. "Where to Live: A Meteorological Problem," D. Brunt. 9 p.m.

Friday, March 28th.—21, Albemarle Street, W.1. "Eclipsing Variable Stars," Sir Harold Spencer Jones. 9 p.m.

Royal Statistical Society

Monday, March 24th.—SHEFFIELD GROUP (INDUSTRIAL APPLICATIONS SECTION): The University, St. George's Square, Sheffield, 1. "The Value of the Factorial Experiment in Chemical Investigations and its Development," K. A. Brownlee. 6.30 p.m.

Sheffield Metallurgical Association

Tuesday, March 25th.—198, West Street, Sheffield, "Reflections on Wartime Steel Inspection," H. Wrighton. 7 p.m.

Societe des Ingenieurs Civils de France

Thursday, March 27th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Reconstruction of the Port of Marseilles," M. Jean Couteaud. 5.30 p.m. (Joint meeting.)

Contracts

STEIN AND ATKINSON, Ltd., has received an order from John Lysaght, Ltd., Scunthorpe, for one-way fired soaking pits of the surface combustion type. The order comprises twelve pits arranged in three batteries of four, each pit being 25ft long by 7ft 6in wide by 10ft 3in deep.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order from the Iraqi State Railways for nine two-coach diesel-electric units. Three of the units are for the standard-gauge lines from Baghdad to Mosul, and the remaining six, which are of metre gauge, will be employed in generally augmenting the rail services out of Baghdad. Each two-coach unit will be fitted with an English Electric 275 h.p. diesel-electric power unit, and will be capable of running at speeds up to 50 m.p.h. Units can be joined together, if necessary, to form a larger train. The order also includes one 350 h.p. diesel-electric shunting locomotive, which will be capable of starting and hauling trailing loads of up to 1000 tons on standard-gauge lines.

Personal and Business

MR. S. E. M. BRANSON has been appointed chief engineer of Richard Crittall Industrial Plant and Equipment, Ltd.

MR. H. H. WESTBROOK, A.M. Inst. C.E., has been appointed principal engineer in the Kent County Architect's Department.

TECHNICAL PRODUCTS, Ltd., announces that its name has been changed to Shell Chemicals, Ltd. The company's address remains 112, Strand, W.C.2.

MR. W. B. D. BROWN, managing director of the Glacier Metal Company, Ltd., has agreed, at the request of the President of the Board of Trade, to serve on the first Council of the British Institute of Management.

RUSTON AND HORNSBY, Ltd., announces that Mr. V. W. Bone has been appointed deputy chairman, continuing in the office of managing director. Mr. E. W. Spalding and Mr. V. R. Prehn have been appointed directors.

MR. F. B. JOHNSTON has resigned from the board of Chadburns (Liverpool), Ltd., on account of ill-health. Mr. E. A. Mearns has been appointed a director and Miss I. M. Shallcross has been appointed secretary of the company.

THE ROCKWELL MACHINE TOOL COMPANY, Ltd., has been appointed sole selling agents in the United Kingdom for all industrial applications of V.S.G. variable-speed hydraulic transmission units and pumps made by Vickers-Armstrongs, Ltd.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., announces that Mr. Sydney Smith, M.I. Mech. E., has been appointed managing director in succession to the late Mr. J. Foster-Smith. Mr. Colin J. Barker has been appointed a director.

MR. A. M. ANDERSON, M.I.E.E., formerly of the Witton works of the General Electric Company, Ltd., and lately general manager of the G.E.C. Leicester factory, has been appointed personal assistant to Sir Harry Railing, Chairman of the company.

THE BOARD OF TRADE announces the appointment of Mr. James H. Ewing as head of an official Mission in Tokyo, to be in charge of sales to, and purchases from, Japan made on Government account on behalf of the United Kingdom, the Colonies and certain other areas.

TUBE INVESTMENTS, Ltd., announces the following appointments:—Mr. D. Lacy-Hulbert, director of production in the precision tubes division; Mr. E. D. E. Andrewes, director and general manager of T.I. (Export), Ltd.; and Mr. Arthur Chamberlain, deputy managing director of the Hercules Cycle and Motor Company, Ltd.

DAVIDSON AND CO., LTD.—Last week we were invited by Davidson and Co., Ltd., of Sirocco Engineering Works, Belfast, to inspect new and enlarged offices at Morris House, 1-5, Jermyn Street, London, S.W.1. The whole of the fourth floor of the building has been adapted to provide modern office accommodation for the administrative and representative staffs, with drawing-office and estimating departments in addition to the secretarial and typing offices. Guests were received by directors of the firm, including Mr. Savill O. Hicks, M.I. Mech. E., A.M. Inst. N.A., the London director. The telephone number of the new offices is Whitehall 3541-8.

Launches and Trial Trips

LEPTON, motor oil tanker; built by Harland and Wolff, Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length 446ft, breadth 54ft 3in, depth 31ft. Engines, Harland-B. and W. four-cycle, crosshead type, with six cylinders, 650 mm bore by 1400 mm stroke. Trials completed, February 6th.

MARENGO, cargo liner; built by Swan, Hunter and Wigham Richardson, Ltd., for the Wilson Line, Ltd.; length 419ft 6in, breadth 55ft 6in, depth 28ft 3in, 7000 tons deadweight. Engines, single-screw, triple-expansion, with an exhaust turbine on the Bauer-Wach system; boiler pressure 225 lb. Launch, February 5th.

PORT PIRIE, twin-screw motorship; built by Swan, Hunter and Wigham Richardson, Ltd., for the Port Line, Ltd.; length 498ft 3in, breadth 68ft, depth 42ft 0½in, gross tonnage 10,560. Engines, two five-cylinder Swan Hunter-Doxford balanced, opposed-piston, cylinders 670 mm bore by 2320 mm combined stroke. Trials completed, January 30th.

LAMPANIA, single-screw motor tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length 446ft, breadth 54ft, 3in, depth 31ft, 9000 tons deadweight. Engines, four-cycle supercharged, airless-injection, with six cylinders, 650 mm bore by 1400 mm stroke, developing 2700 b.h.p. Launch, January 7th.

A Seven-Day Journal

The "Monarch of Bermuda" Fire

A SERIOUS fire broke out about four o'clock on Monday morning, March 24th, in the accommodation spaces on one of the upper decks of the Furness Withy 22,424 gross ton turbo-electric liner the "Monarch of Bermuda." Only a few days ago the ship, which reached the Tyne on January 12th, had entered the dock at the Hebburn-on-Tyne shipyard of Vickers-Armstrongs, Ltd., for a hull survey, and the possible replacement of shell plates. The workmen engaged on the ship had, it appears, left for the week-end on Friday evening, and only the fire patrol was aboard. The flames were fanned by a prevailing north-east wind, The fire was bravely fought by some 200 firemen from various North-East Coast N.F.S. units, and five of the firemen were sent to hospital with injuries. It burned for twenty-six hours, and was finally extinguished on Tuesday. Serious damage has been done, it is reported, to the officers' and passengers' accommodation, particularly on the sun and boat decks, the bridge and the A to E decks below. It is feared that large quantities of water have reached the turbo-alternators, boilers and the main propelling motors, and that considerable damage has been done to the main and auxiliary electrical machinery. The "Monarch of Bermuda" was built at the Vickers-Armstrongs Walker yard in 1931, and was engined by the General Electric Company, Ltd.

Electricity Load Shedding

DURING his chairman's address at the recent annual meeting of the County of London Electric Supply Company, Ltd., Sir Robert Renwick commented on the shedding of the electricity load and on the effects of the shortage of generating plant. He emphasised that neither the companies nor the municipal undertakings were in any way responsible for the shedding of load on the recent emergency electricity restrictions. The Central Electricity Board's estimates had to be stepped up sharply at a late stage because the Ministry of Fuel and Power had failed consistently to live up to its promised deliveries of coal. The crisis arose, Sir Robert stated, because coal deliveries, due before the cold spell, were short of allocated quantities, and not because of any substantial error in estimating requirements. Regarding load shedding owing to the shortage of generating plant, Sir Robert said that far and away the biggest contributory factor was the entirely inadequate rate at which new plant had been and was being brought into commission since the end of the war, on account of lack of Government priority. Sir Robert thought the country would be lucky if, by the end of the present year, the additions to generating capacity since the end of the war totalled 350,000 kW. In 1948 it might get an additional 615,000 kW, yet at present it was short of some 2,000,000 kW. Comparing present progress with that achieved in 1941—one of the blackest years the country had ever faced—Sir Robert said that in that year the additional generating capacity installed was 700,000 kW, and in 1942 capacity totalling another 700,000 kW was provided.

North of Scotland Hydro-Electric Board Progress

THE North of Scotland Hydro-Electric Board has lost no time in starting work on the Mullardoch-Fasnakyle-Affric project (see THE ENGINEER, October 18, 1946), and the first major contracts have now been placed. The whole of the civil engineering work will be carried out by John Cochrane and Sons, Ltd., of 39, Victoria Street, London, and Inverness. The English Electric Company, Ltd., has been given the order for supply and erection of three 22,000-kW turbo-alternators for the Fasnakyle generating station. The alternators will be driven by three 33,000 h.p. vertical shaft Francis turbines. Arrangements are also completed for the erection of the camps which will house the peak number of 2000 men who will build the dams and power stations and drive the tunnels which will carry the water from Loch Mullardoch to Loch Benevean and from Loch Benevean to the power station at Fasnakyle. Preliminary negotiations in connection with the transmission of electricity from Fasnakyle to Beauly have begun. The Board is also pressing ahead with other major projects. At Loch Sloy men are working night and day on the tunnel through Ben Vorlich. The foundations of the generating station at Loch Lomondside are being excavated, and work will soon start on the diversion of the main Balloch-Crianlarich Road. Plant which will be used in the construction of the dam at Loch Sloy is being assembled on the site and work will begin in the near future. At Pitlochry the site of the Clunie power station is being excavated, and preliminary tunnelling in connection with the 23ft diameter Clunie tunnel which will carry water from Loch Tummel to Clunie generating station is being carried out. Work is also starting on the Clunie dam at the east end of Loch Tummel, and the construction of a cofferdam will be begun next month. At Fannich accommodation camps are under construction and the oil-electric power station plant, which will supply electricity during construction of the project, is being assembled. The contract for the 3½-mile long, 10ft diameter tunnel has been placed with Balfour, Beatty and Co., Ltd.

Radiocommunication Convention

ON Tuesday, March 25th, Sir Stafford Cripps, President of the Board of Trade, opened the Radiocommunication Convention at the Institution of Electrical Engineers in London. Delegates from a number of countries, including France, Switzerland, Holland, China, Russia and the U.S.A., formed part of the large audience which foregathered to hear an account of Britain's contribution to the science of radiocommunication during the war years. Although this particular contribution was less spectacular than the corresponding achievements in radiolocation, the progress made in radiocommunication has special significance because of its peacetime importance. At the opening meeting Colonel Sir Stanley Angwin delivered an address on "Telecommunications in War." Skilfully condensing into an hour's lecture a subject that covers a very wide field, Sir Stanley outlined the measures taken before the outbreak of war to safeguard and extend inland telecommunication services to meet the anticipated needs of wartime. Line facilities were expanded and set aside for Service use; a number of emergency radio stations, fixed and mobile, which became known as the London Ring Main, were established; and similar measures were applied to the chain of radio stations that control coastwise shipping. On the technical side, one of the outstanding wartime developments was the application of pulse technique to radiocommunication, an interesting example of which was the well-known No. 10 set, which formed an essential link, and at times the only one, between Montgomery's headquarters and No. 10, Downing Street. Sir Stanley emphasised the fine achievement of the radio industry, which successfully met unprecedented demands for complete equipments as well as valves and other components. Much of this success was due to standardisation and the production of miniature components which made possible important reductions in the size and weight of complete radio equipments. The subsequent proceedings of the Convention will, it is hoped, be referred to in later issues of this paper.

Automobile Electrical Equipment and Radio Interference

IN 1933 the Electrical Research Association began large-scale investigations of radio interference from electrical plant and apparatus, including motor vehicle ignition systems. Since interference from the latter source is, in general, serious only in the short-wave regions, the real significance of this part of the work was not manifest until the advent of television broadcasting. On the outbreak of war the television service was suspended, but the problem of ignition interference assumed fresh importance in the radio communication systems of armoured fighting vehicles and small naval craft. During the war therefore these interference problems became the concern of a committee comprising representatives from the Ministry of Supply, the Services, and the leading manufacturers of electrical equipment for the motor industry; the E.R.A. provided the necessary experimental and secretarial assistance, which was financed by the Ministry of Supply. At the end of the war the need was evident for continued research on radio interference matters that were of mutual interest to the Ministry of Supply and to the industry. To enable the E.R.A. to assume its full responsibility on behalf of industry, while giving the maximum assistance to Government Departments, it was decided to constitute an E.R.A. committee, the cost of research being paid from E.R.A. funds assisted by contributions from the Ministry. Accordingly, a new sectional committee of the E.R.A. has been set up to study and develop the electrical equipment of automotive systems, with particular reference to electrical ignition systems, accessories and radio interference suppression devices. The committee comprises representatives from the Ministry of Supply, the Admiralty, the Motor Industry Research Association, the British Internal Combustion Engine Research Association, the Department of Scientific and Industrial Research, and most of the leading manufacturers of electrical components. The chairman of the committee is Dr. E. A. Watson, of Joseph Lucas, Ltd., and the secretary is Mr. W. Nethercot.

The Cost of Living Index

IN August, 1946, the Minister of Labour appointed a committee to advise on the basis of the official cost-of-living index and on relevant matters. Mr. R. M. Gould, Chief Industrial Commissioner of the Ministry of Labour, is the Chairman of the Committee, and an interim report has now been issued as a White Paper (Cmd. 7077). The immediate question which the Committee considered was whether any revision of the basis of the cost-of-living index figure was practicable or desirable in present conditions. The existing index is based on 1914 consumption and expenditure—with the exception of food, for which 1904 is the basis—and the Committee recommends that it should be terminated. It is suggested that, as a temporary measure pending the results of further study and examination, a new index should be instituted, starting at 100, to show future monthly changes in the level of retail prices weighted according to the pre-war pattern of consumption disclosed by the inquiry into working-class expenditure made by the Ministry of Labour in 1937–38. The report also proposes that a technical committee should be set up forthwith to prepare a scheme showing how the information from the 1937–38 inquiry can be best adapted for the purpose. This technical committee, the report adds, when it has prepared a scheme, should then address itself to the problems involved in instituting a regular series of budget collections, which would be needed to help the advisory committee to reach conclusions on the nature of a permanent index to be introduced in due course.

Historic Researches*

No. XXI—MOLECULAR PHYSICS

Daniel Bernoulli (1700–1782) belonged to the second generation of the Swiss family which in the course of a century produced eight distinguished mathematicians and physicists. He was the second son of John Bernoulli, who at the date of Daniel's birth occupied the Chair of Mathematics at Groningen University. Daniel at first studied medicine, but at an early date the mathematical genius of his father and his father's brother James manifested itself also in him. John was a man of difficult temperament and did little to encourage his son's budding ability. Daniel's early mathematical studies were, in fact, fostered not by his father but by his elder brother Nicholas, in whom the family genius also shone. After a period of study in Italy, Daniel, at the age of twenty-five, was appointed Professor of Mathematics at St. Petersburg. In 1733 he returned to Switzerland to take up the professorship of anatomy and botany at Basel University. Later he was transferred to the Chair of Experimental and Speculative Philosophy. In that office he remained until he was eighty, when he was relieved of his duties by one of his nephews, James Bernoulli the second. In his celebrated "Hydrodynamica," published in 1738, he laid the foundations of the modern science of hydraulics. That work included an analysis of the impact theory of gaseous pressure and described a method of propelling vessels by the reaction of water ejected from the stern. In his later years he devoted much of his attention to the doctrine of probabilities and its application to economic subjects. A century or so later Clerk Maxwell applied the doctrine of probabilities to the theory of gaseous pressure and carried that theory far beyond the stage at which Bernoulli had been compelled to leave it.

BY the year 1870 the atomic theory of chemistry, founded by Dalton, had become universally accepted by chemists. They were convinced that the atomic structure of matter was no ancient Greek dream, but that it was a very practical reality, and that it was the key to the understanding of many, most or all chemical phenomena.

The atomic hypothesis, however, was not solely of chemical interest. It clearly also had physical implications and if it were sound ought to be capable of explaining physical phenomena as successfully as it explained chemical phenomena. What had the physicists to say on this point?

In actual fact, by 1870 they had a great deal to say about it. Their minds had been turned towards the subject long before Dalton developed its chemical aspects. For 200 years they had indulged in unconfirmed speculation concerning it and had made little real progress. Then in 1848 Joule provided them with a vital clue which had been entirely omitted from their deliberations, a clue which enabled them to turn their speculations into a well-founded theory. A flood-tide of development quickly set in, and by 1870 physicists were able to join their chemical brethren in support of the atomic hypothesis. It is our purpose here to recall the history of the subject on its physical side during these twenty-odd years and to show how by the interplay of speculation and practical experiment, the dynamical theory of gases came to be established.

During the prolonged period of desultory speculation which preceded Joule's time, natural philosophers approached the physical aspects of the atomic hypothesis from but one direction—to them, and still to us, the most obvious. They sought to find in it an explanation of the primitive fact that matter in the solid state exhibited cohesion while in the gaseous state it showed the opposite characteristic, a tendency to expand and fill uniformly any vessel in which it was confined. Herein they saw a paradox. Could the atomic hypothesis reconcile it?

Newton was the first seriously to attempt a detailed answer to this queston. He suggested that the atoms of matter were centres of force, that when they were close together as in a solid the force was attractive, and that when they were far apart as in a gas it was repulsive. At some intermediate degree of separation there would be neither attraction nor repulsion. This general absence of interatomic force, it was to be supposed, was characteristic of the intermediate state of matter and explained the mobility of liquids.

In some subsidiary respects this supposition presented certain obscure features, but, on the whole, it seemed to be reasonable enough. Newton therefore proceeded to study it mathematically. He quickly discovered good reason for discarding it. He found—and it is quite easy to confirm his result—that if Boyle's law governing the relationship between the pressure and volume of a gas were to hold good, the atomic repulsion giving rise to the pressure must vary inversely with the first power of the distance between the atoms and not in proportion to the inverse square of that distance, as in the case of gravitational attraction. There was nothing unacceptable about this conclusion by itself, but it involved a corollary which was completely irreconcilable with observed fact. If the law of repulsion were as stated, the pressure of a gas, in addition to varying with the volume, should depend in a marked degree upon the shape of the containing vessel.

Nothing discovered since Newton's time has shaken the validity of this conclusion. The expansibility of gases and the pressure which they exert against the walls of their containers cannot be satisfactorily explained on the supposition that their atoms repel one another. If any interatomic repulsion exists, its amount, at the distances of separation occurring in gases, can contribute little or nothing to the pressure exerted. This finding does not, of course, automatically rule out the possibility of interatomic attraction being the cause of cohesion in solids.

Newton was obsessed with his conception of central forces as the mainspring of all material phenomena. It was therefore natural that he should seek an explanation of gaseous pressure in the existence of interatomic force of one kind or another. He treated the subject statically. Although he accepted the old Greek doctrine that the atoms of matter were "endowed with ceaseless motion," he ignored their motion in his study of the repulsion theory of gaseous pressure. He seems to have justified this procedure by arguing that the atomic motion could be neglected because it merely changed the positions of the individual atoms from instant to instant without altering the general pattern of their distribution.

Other philosophers of the period were disinclined to ignore the motion of the atoms. In 1649, when Newton was barely seven years old, Pierre Gassendi, an eminent French scholar, had led a revival of interest in the atomism of Democritus and had declared his conviction that all material phenomena could be traced to the motion of the indestructible particles of which matter was composed. Some twenty years later Robert Hooke, adopting the same general idea, advanced it specifically as an explanation of gaseous pressure. He suggested that the pressure was produced by the impact of the moving atoms against the walls of the containing vessel and not by virtue of the existence of interatomic repulsive forces.

It is possible that Newton, then at the height of his powers, was blinded by his jealousy of Hooke to the merits of this suggestion. He was well fitted to follow it up and examine its mathematical implications. He did not do so. Nearly eighty years had to elapse before another mathematical genius took up Hooke's general idea and turned it from a wholly unconfirmed speculation into a promising theory. In 1738 Daniel Bernoulli, in his celebrated work on hydrodynamics, published a mathematical analysis of the pressure produced by the impact of gaseous atoms against the walls of a containing vessel. He reached a result of great significance—greater than he himself was in a position to realise.

It is essential, if we wish to follow the subsequent history of the subject with proper understanding, to acquaint ourselves with the gist of Bernoulli's argument. It is not difficult to do so when it is presented in modern terms instead of in those actually used by Bernoulli. In one particular respect it is not only convenient, but important to modernise the argument. We must cease to speak about the movement and impact of the *atoms* of a gas and use instead the word *molecules*—a term unknown to Bernoulli. The subject of our immediate interest is the force produced by the impact of the smallest particles of a gas which move, strike the walls of the containing vessel and rebound therefrom as undivided physical entities. These particles, so long as no question of dissociation arises, are the molecules of the chemist. To the physicist it is immaterial, at least in the preliminary stages of the discussion, whether the molecules consist of one, two or more atoms.

Bernoulli's argument, as we shall here present it, is based on certain assumptions. In the first place, it is assumed that all the molecules of the gas under consideration have the same mass. The argument can, however, be readily extended without affecting its validity to cover the case of unequal molecular masses. It is thus applicable both to a pure gas and to a mixture of two or more pure gases which do not unite chemically with one another.

We know from experience that the pressure exerted by a gas confined in a cubical vessel is the same on all six faces. Hence, if the pressure is produced by the impact of the molecules against the faces, and if all the molecules have the same mass, we may reasonably suppose that one-sixth of the

* Nos. I, II and III on "Friction" appeared July 14, 21, and 28, 1944; Nos. IV, V and VI on "The Mechanical Equivalent of Heat," appeared September 29, October 6 and 13, 1944; Nos. VII, VIII and IX, on "Electro-Dynamics," appeared March 9, 16 and 23, 1945; Nos. X, XI and XII, on "The Ether Drift Experiments," appeared August 3, 10 and 17, 1945; Nos. XIII and XIV, on "Specific, Latent and Atomic Heats," appeared December 7 and 14, 1945; Nos. XV, XVI, XVII and XVIII, on "Chemical Elements and Atoms," appeared August 2, 9, 16 and 23, 1946; Nos. XIX and XX, on "The Classification of the Elements," appeared September 27 and October 4, 1946.

total number of molecules comprising the gas will be responsible for the pressure exerted on each of the six faces. At any instant therefore one-sixth of the molecules will be moving towards each face. They will approach it along variously inclined paths. We are, however, concerned only with the components of their velocities normal to the face, since the components parallel with it can contribute nothing to the impact effect. We are thus led to picture the actual movements of the molecules as being replaced by six streams each containing one-sixth of the total number of molecules and each moving normally towards one of the six faces of the cubical container.

The velocities of the molecules in any one stream will doubtless vary from molecule to molecule. It is, however, legitimate to presume that there is some mean velocity which if they all possessed it would produce the same impact effect as that produced by their actual varying velocities. The nature of this mean velocity will be considered subsequently. It will be found to lead us to the very root of our subject.

It has further to be assumed that the mean velocity is the same for all six streams, and that it remains unaltered after the molecules have struck the face of the container towards which they are moving and rebounded from it towards the opposite face. The implication here is that the molecules of the gas and of the material of which the container is made possess perfect elasticity; that is to say, that the impact of the gas molecules against the face produces no net loss or gain of kinetic energy in the gas molecules. This assumption is in harmony with the practical fact that the pressure of a gas hermetically sealed in a vessel and preserved at constant temperature neither decreases nor rises with the passage of time.

On the basis of these various assumptions it is quite easy—see the attached mathematical note—to calculate the pressure which should be produced by the impact of the molecules against the faces of the cube. The formula arrived at is $p=\frac{1}{3}nmv^2/s^3$, where n is the total number of molecules composing the gas, m is the mass of one molecule, v is the mean molecular velocity defined above and s is the length of side of the cubical container. Since s^3 is the volume V of the container and since nm is the total mass M of gas inside it, we can rewrite this formula as $pV=\frac{1}{3}Mv^2$.

Since M, the mass of the gas, is constant, this relationship taken in conjunction with Boyle's law, pV=constant, implies that the mean velocity v must remain unchanged when the volume V of the container is increased or decreased. In other words, the rise in pressure which accompanies a diminution in volume is not to be ascribed to any increase in the velocity with which the molecules strike the walls of the container, but entirely to the increase in the number of impacts occurring in a given time. Conversely, if the volume increases, the faces of the vessel become farther apart, the molecules—moving with the same mean velocity as before—take longer to travel from face to face, the number of impacts per second is decreased and the pressure falls off.

Bernoulli grasped this implication of his result. He also seems to have realised in some measure the significance of the fact that Boyle's law applies to the compression or expansion of a gas at constant temperature. It is not true if the temperature is allowed to change. The obvious inference is that if the temperature changes, the mean velocity v of the molecules ceases to remain constant. The mean velocity thus appears to be dependent upon the temperature, or, to put it the other way round, the temperature of a gas is an expression of the mean velocity of its molecules.

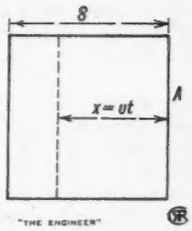
Beyond this point Bernoulli was unable to proceed. He must, however, have seen that, given accurate experimental data, his formula $pV=\frac{1}{3}Mv^2$ provided a means of determining the absolute value of the mean velocity of the molecules of any gas. The times were, however, unpropitious. Laboratory apparatus and methods in 1738 were crude. In addition, chemists still laboured under erroneous ideas concerning gases and had no means of preparing them in a pure state. The essential data required by Bernoulli consisted of values of the density of different gases. The first reasonably accurate knowledge of the density of any gas in a comparatively pure state did not become available until 1766, when Cavendish published the results of his experiments on the specific gravity of "inflammable air" or hydrogen.

Let us carry out, with the aid of modern experimental values, the calculation which Bernoulli was unable to perform. A litre of hydrogen at 760 mm and 0 deg. Cent. is found to weigh 0·08985 gm. A litre is 1000 c.c. and 760 mm of mercury is equal to an absolute pressure of 1·0132 million dynes per square centimetre. Using these figures in Bernoulli's equation, we find that the mean velocity of the molecules of hydrogen at standard temperature and pressure comes out at 1840 m per second, or roughly 69 miles a minute. For any other gas at the same temperature and pressure, Bernoulli's formula in its first form shows that the mean molecular velocity will be proportional to the inverse square root of the relative molecular weight. The molecular weight of hydrogen is 2 and that of oxygen is 32. The mean velocity of the molecules of oxygen at standard temperature and pressure will therefore be one-quarter that for hydrogen or 460 m per second. Mercury vapour has a molecular weight of 200·6. Hence the mean velocity of its molecules at standard temperature and pressure is about one-tenth that for hydrogen, or, say, 7 miles per minute—about two-thirds the speed of a "Meteor" aeroplane.

Returning to Bernoulli's equation in the form $pV=\frac{1}{3}nmv^2$, we to-day recognise at once that since $\frac{1}{2}mv^2$ is the kinetic energy of a single molecule, the right-hand side of the equation is equal to two-thirds of the total kinetic energy of all the molecules inside the vessel. We can therefore rewrite the equation in yet another form, namely, $pV=\frac{2}{3}E$. Bernoulli could not have grasped the significance of this simple development of his formula. In his day the conception of energy had scarcely been formed. It still lay hidden behind the vague terms *vis mortua* and *vis viva*, which Leibnitz had applied to what we now call respectively potential energy and kinetic energy.* Hence even if Bernoulli had rewritten his equation as $pV=\frac{1}{2}$ *vis viva* it would have meant nothing to him, other than that the total quantity of the mysterious entity called *vis viva* possessed by a given mass of gas remained constant when the volume and pressure of the gas altered in accordance with Boyle's law.

No further development of the subject was possible until physicists and chemists had rid their minds of many false ideas and by diligent practical research had accumulated a store of authentic experimental data. Over a century—a century as revolutionary in the domain of science as it was in politics—passed by before physicists were ready to take up the subject at the point at which Bernoulli had l ft it.

Mathematical Note.—Consider a cube of side s containing a mass M of gas at pressure p and temperature T. Let n be the number of molecules comprising the gas. Then at any instant $\frac{1}{6}n$ of the molecules are to be supposed to be moving with a uniform mean velocity v towards each of the six faces of the cube. Consider the face A. Of the $\frac{1}{6}n$ molecules moving towards it at any instant, the number that will strike it during an interval of time t will be those which at the start of the interval lie at a distance from A not greater than $x=vt$. The number within this striking range x will bear



to the total number in the stream the same ratio as x bears to s. Hence the number of molecules which strike A during the interval t will be $\frac{1}{6}n \cdot vt/s$, and if m is the mass of each of them, the momentum which they possess will be $\frac{1}{6}nmv^2t/s$. At the end of the interval t this momentum will have been reversed in direction, and therefore the total change of momentum during the interval will be twice the above quantity. Dividing by t we get the rate of change of momentum or the total force applied to the face A by the impact of the molecules. Dividing again by the area s^2 of the face, we get the corresponding pressure as $p=\frac{1}{3}nmv^2/s^3$, or $pV=\frac{1}{3}Mv^2$.

(To be continued)

The Institute of Metals

No. III—*(Continued from page 235, March 21st)*

ON resuming, on Thursday morning, the first paper presented was :—

A NOTE ON THE SELECTIVE CORROSION OF PHOSPHOR-BRONZE IN HOT-WATER SERVICE.

By W. D. Clark, M.A., M.Sc., Member.

Synopsis

Phosphor-bronze pump impellers handling hot feed water and condensate on a power station have been found to be suffering from a form of attack analogous to dezincification. Micrographic, analytical, and X-ray evidence of the nature and products of the attack is presented. The castings were highly porous, and water penetrating down the pores has led to the formation of particles of copper and stannic oxide deep in the metal. This serious attack has taken place from a machined surface, where the pores were exposed. On a surface not machined, attack is not very important, but has produced a number of structures which are not understood.

Discussion

Dr. Ulick R. Evans said the author was quite right in bringing out the parallelism with the well-known phenomenon of the dezincification of brass. The work of Fink, which was done in his laboratory many years ago, showed that in the dezincification

* More accurately, kinetic energy $=\frac{1}{2}$ *vis viva*.

of brass there could be both residual copper and re-deposited copper; and Dr. Evans recalled that the appearance of the two types was quite different. After discussing the theory, he said that in the brasses and bronzes we could expect true residual copper to be obtained only at certain unfortunate points on the surface; but once a trifle of residual copper was produced, and once there was a small residue of, say, basic copper salt, the stage was set for the other change, which involved only a very small electrical resistance, namely, the deposition of copper from the reservoir of copper compounds on the copper nucleus as cathode, and the resolution both of copper and the other constituent, replenishing the supply in the reservoir. Once it was started, it could go on indefinitely.

Clearly, we were dealing with a probability effect, and it was all important to consider the factors which affected the probability of the process starting because, having started, it was likely to go on; and the same was almost certainly true of destannification also. That also depended on the previous thermal history of the material. Brass was much more susceptible to it if the treatment had been such as to produce relatively zinc-rich compounds between the grains. If there were small amounts of the β phase in a brass which should be purely α, it was more likely to start. If the material were porous, and if, owing to the original surface machining, the pores had been given access to the outside, then the effective area available for the starting of that unfortunate process became larger than if the material were non-porous.

Mr. T. Henry Turner (L.N.E.R.) wondered why the same phenomenon was not found in other alloys, and asked whether it was just a matter of temperature or a fundamental characteristic of a particular mixture. The L.N.E.R. used phosphor-bronzes under steam conditions and did not encounter that trouble. If one used aluminium-bronze, however, then under the same working conditions of temperature and waters de-aluminification occurred.

He had encountered the same thing in the dezincification of condenser tubes. There again the original forged structure was lost; instead of that, one found that growing from a point there were concentric circles of copper, of increasing diameter. That would suggest that the copper had been dissolved and re-deposited. But he did not know that that was the only suggestion.

Mr. A. J. Murphy recalled that in aluminium-bronze he had found the presence of SO_2 rather important in the initiation and continuation of the attack. Where aluminium-bronze was used in articles such as water-cooled moulds for glass, the purification of the water which impinged on the superheated bronze was rather important, and he wondered if the author would be inclined to look even more critically at the make-up of the water used in the case discussed in the paper, to see whether there was something corresponding to SO_2 which functioned in an analogous way with the tin-containing bronzes.

Mr. Roy A. U. Huddle said that in the discussion it had been assumed that the production of the pure copper was by dezincification, mainly on the grounds of the probability of that happening. It seemed to him, however, that there was no reason why it should not be a simple diffusion phenomenon. The corrosion seemed to be a simple case of the attainment of equilibrium, *i.e.*, a tin-copper phase in the presence of oxygen reverting to tin oxide and copper. If it carried on it might become tin oxide and copper oxide.

Mr. John Arnett urged that the original porosity of the casting was a very important factor. The use of alternative materials to overcome the problem discussed in the paper was relatively simple. Stainless steel had been hinted at, and there was evidence that the high-nickel cupro-nickel alloys were completely resistant to the action mentioned by the author.

Mr. Clark, replying, said that in effecting a cure, castings of less porosity were first tried. But phosphor-bronze castings of those sizes, having low porosity, were not so easy to get. Then they had considered whether they could safely reduce the tin content. For that type of job the 10 per cent tin alloy was the traditional material. They had considered using 7 per cent, or even less, particularly bearing in mind that during the war tin was short, but they had not proceeded very far with that. The sealing of the castings with some type of plastic was considered, but the temperatures militated rather strongly against that, except for certain of the pumps which did not give trouble anyhow. For pumps used in the hottest conditions and with the worst water they would probably use ferrous materials.

Dealing with Mr. Turner's point that 95/5 phosphor-bronze did not appear to give trouble, but aluminium-bronze gave considerable trouble, he said that perhaps that was because the lower the tin content the less was the likelihood of the trouble occurring. The diffusion and selective solution theory discussed by Mr. Huddle did not satisfy the observed facts.

The next paper presented was:—

MAGNESIUM-CERIUM-ZIRCONIUM ALLOYS: PROPERTIES AT ELEVATED TEMPERATURES.

By A. J. Murphy, M.Sc., Member, and R. J. M. Payne, B.Sc., Member.

Synopsis

Sand-cast binary magnesium-cerium alloys containing about 3 per cent cerium (mischmetall) possess good strength and resistance to creep at 200 deg. Cent. They are not hot-short or liable to serious shrinkage troubles, and cast well in sand moulds. Their mechanical properties at ordinary temperatures are, however, poor.

By the addition of zirconium, alloys are obtained which have mechanical characteristics at room temperature comparable to those of the usual casting alloys Elektron A8 and AZ91 (specifications D.T.D. 59a and 136a), but possessing resistance to creep of a far higher order. When tested at 200 deg. Cent., the creep-resistance of certain of the magnesium-cerium-zirconium alloys is very little inferior to that of the widely used aluminium alloys of the type covered by specifications D.T.D. 133c and 287. The combination of good casting qualities and good mechanical properties at ordinary and elevated temperatures makes the magnesium-cerium-zirconium alloys attractive for some important lightweight stressed components of engines, for which magnesium-base materials have hitherto been unsuitable.

The good creep-resistance of the magnesium-cerium-zirconium alloys is shared by the quaternary alloys formed by the addition of such elements as zinc and silver.

Discussion

Mr. F. A. Fox was particularly interested in the paper because it was the first to appear in print dealing with the grain refining effect of zirconium alloys. That was a case where creep properties appeared to be very beneficially influenced by grain refinement, rather than the other way round, which was the more common experience. It was interesting also to note the increasing importance in the magnesium field, and possibly the light alloy field generally, of creep properties as distinct, say, from high temperature fatigue properties; and the jet engine development might lead to greater emphasis on the creep characteristic. The tests reported in the paper showed, as he had found with magnesium-elektron, that high temperature short-time tensile tests were practically valueless in assessing magnesium alloys for elevated temperature work.

There was perhaps a slight difficulty in the title of the paper, in that the alloys were "mischmetall" alloys rather than cerium alloys. The authors had drawn attention to that, and it should be borne in mind that they were not dealing with a simple system but with a mixture of various metals, and the alloys might not be so simple in their behaviour as it would appear. It was also important to remember that the "mischmetall" to be used for the work must have low iron content and, therefore, must be rather special material, because if the iron concentration were high, one was liable to precipitate the zirconium and consequently lose the grain refining effect, which proved to be so critical.

Mr. Payne, replying, said the point that the creep properties were improved by the addition of zirconium was not borne out by the work discussed in the paper or by work which the authors had done subsequently. The mechanical properties at ordinary temperatures were changed considerably and were brought to a useful level by the addition of zirconium, but the creep properties were not greatly affected. The early creep tests on the binary alloys and those with the low degree of grain refinement showed that those alloys had a useful resistance to creep, and the others, with a high degree of grain refinement, did not show a very great improvement above those. Indeed, they were a little relieved to find that the creep properties were not improved by the high degree of grain refinement achieved by the addition of zirconium.

The authors had not made tests using cerium, which had been isolated from the other elements of the rare earth group; but there had been nothing in the present work to indicate that there would be any appreciable difference of behaviour in use.

The final paper taken on Thursday was:—

SOME FACTORS IN THE REDUCTION OF THE IRON CONTENT OF MAGNESIUM-BASE ALLOYS.

By F. A. Fox, M.Sc., Member, C. J. Bushrod, M.Sc., and S. E. Mayer, Ph.D., Student Member.

Synopsis

Small quantities of iron, present as an impurity, are removed from magnesium base alloys by allowing manganese-rich particles to settle out of the molten alloy. The authors carried out experiments to establish the optimum conditions for this mechanism to operate.

Although the removal of iron from magnesium-aluminium alloys is efficiently carried out by the process, particularly if two successive settling operations are employed, it is not so readily accomplished in the case of binary magnesium-manganese alloys. Virgin melts do not give such good results after treatment as do melts containing considerable proportions of secondary ingot, apparently because of the lower initial iron content of the latter.

Possible mechanisms for the iron-removal process are discussed in relation to the results of small, medium and large scale settling experiments.

Additional experiments were carried out to ascertain the most suitable steel for making crucibles for remelting the alloys of low iron content. A high-manganese, high-carbon austenitic steel gave the most interesting results. A "seasoning" effect was detected whereby suspended samples

of crucible material appear to contaminate a melt, held in a graphite pot, at a progressively decreasing rate.

Evidence is given in Appendix I to show that the ratio of manganese in solution to that out of solution is of great importance in connection with the corrosion behaviour of the binary magnesium-manganese alloys.

Discussion

Mr. A. J. Murphy said that the work described in the paper was immensely valuable, very largely because of the broad field which it covered. But he was in complete disagreement with the authors regarding the suitability of mild steel vessels for melting high-purity magnesium. There was an indication in the paper that, provided a mild steel vessel had been "seasoned" by numerous preliminary meltings, then in meltings of high-purity magnesium there would not be an objectionable pick-up of iron. Mr. Murphy, however, mentioned some results, in connection with some 20 lb melts of high-purity alloys—he would give details in a written contribution—where it was found that, by heating to a temperature not exceeding 800 deg. Cent., or by super-heating to 900 deg. Cent. and using the ordinary flux technique, metal which initially had contained 0·0005 per cent of iron always picked up a considerable amount of iron.

Mr. Roy A. U. Huddle, discussing the significance of precipitates in corrosion resistance, said it seemed a perfectly general principle that, where alloys were made for corrosion resistance, it was absolutely essential to avoid certain precipitates which raised the potential of the solid solution. Therefore, he suggested that in industrial research with the object of improving corrosion resistance—and that seemed the ultimate aim of the work described in the paper—experiments should be undertaken to measure the potential of the final product corroding in the solutions which were likely to be used in practice, because, if the potential were elevated, in all probability the precipitate was playing a very important part.

Dr. Pfeil asked if the authors could say something about the nature of the interface between an iron or a manganese steel crucible and the molten magnesium alloy, and similarly, of the probable interface between a specimen of iron and the magnesium in which it was suspended in connection with experiments in the study of iron pick-up. He visualised that an iron crucible in service would pick up some sort of iron oxide film; then, in the course of the next melting operation, he visualised some reaction between magnesium or the constituents in the magnesium alloy and the iron oxide film, perhaps reducing that film and giving finely divided iron which was quickly soluble, and finally developing a clean interface, with opportunities for rapid reaction. He also asked for information as to the probable nature of the iron compound which was precipitated.

Dr. Hugh O'Neill, referring to the decarburisation of steels, said it was easy to appreciate that the fluxes used might have carried out the decarburisation which the authors had suggested. But he did not know that the paper contained spectrographic or chemical proof that decarburisation had actually occurred. He asked whether the carbon could have been pushed back from the surface by the penetration of some other element, which would tend to give a carbon concentration below the original surface.

Dr. Mayer replied shortly.

(To be continued)

Desulphurisation and Dephosphorisation of Iron

No. I

MEETINGS at which the Iron and Steel Institute, the Institute of British Foundrymen and the British Iron and Steel Research Association took part were held at No. 4, Grosvenor Gardens, London, S.W.1, on March 19 and 20, 1947. Recent and future research problems were discussed in connection with the desulphurisation and dephosphorisation of cupola iron and pig iron, and side-blown converter practice.

On Wednesday, March 19th, the meeting was held jointly by the Institute of British Foundrymen and the Iron and Steel Institute. Mr. D. Howard Wood (President of the Institute of British Foundrymen) presided. Three reports dealing with the desulphurisation and dephosphorisation of cupola iron and pig iron, giving the results of co-operative work under the auspices of the Technical Council of the I.B.F., were presented and discussed.

The Chairman, opening the meeting, expressed the hope that co-operation on such matters would benefit the industry. It was the supply position during the war, he said, which had brought into existence the Basic Cupola Sub-Committee of the Technical Council of the I.B.F., whose reports were to be discussed.

Sir Charles Goodeve, F.R.S., Director of the Research Association, said the reports provided a good example of co-operative research work between firms with common problems who had put their experiences together for the common benefit. The Institute of British Foundrymen had shown the way to co-operative research very clearly in that particular field, and arrangements had been made to carry on the work.

Mr. L. W. Bolton (of John Gardom and Co., Ltd., and Chairman of the Sub-Committee) introduced the first and second reports, of which synopses appear below.

FIRST REPORT ON THE BASIC CUPOLA*

In cupolas with acid, *i.e.*, firebrick and ganister linings, it is not possible to produce the basic slag necessary to reduce the sulphur and phosphorus contents of the metal during melting. In certain applications, for example, in the melting of ferro-manganese, excessive wear is experienced on acid linings. Improvements in basic refractories and the development of a stabilised dolomite patching cement has caused renewed interest in the possibilities of lining cupolas with basic material.

A monolithic lining of stabilised dolomite was installed in a small cupola melting ferro-manganese used in the production of manganese steel. The lining withstood the melting conditions better than a firebrick lining and erosion was reduced.

A lining of stabilised dolomite when used in a cupola of 36in bore enabled metal to be produced with a sulphur content less than 50 per cent of that normally expected when melting similar mixtures with an acid lining.

The possibilities offered by the basic cupola of obtaining dephosphorisation during melting were examined. In preliminary melts using charges of low silicon (0·77 per cent silicon) pig iron containing 0·74 per cent phosphorus, iron ore was added with the charges to assist in creating an oxidising slag. Phosphorus removal varied from 5 to 50 per cent, and was almost dependent on silicon removal. Samples which showed the maximum silicon loss also showed maximum dephosphorisation. When the charged metal contained 0·05 per cent silicon and 0·6 per cent phosphorus, the phosphorus content was reduced by 80 per cent without the addition of an oxidant. The inclusion of ferro-silicon in the charge reduced the dephosphorisation to about 40 per cent, but the reduction was not in proportion to the amount of ferro-silicon added. Oxidising conditions favourable to dephosphorisation were found to restrict desulphurisation.

* "Proceedings" of the Institute of British Foundrymen, 1943-44, Vol. XXXVII, pages A133-A146.

SECOND REPORT ON THE BASIC CUPOLA†

A cupola of 90in bore was provided with a monolithic lining of stabilised dolomite. Charges of 100 per cent steel scrap were used for steel making by the converter process. Silicon additions to the charges were kept to a minimum, and the possibility of obtaining dephosphorisation of already low-phosphorus metal during melting was studied.

The average run of steel scrap used in the experiments contained 0·065 to 0·085 per cent phosphorus. Some measure of dephosphorisation and desulphurisation was obtained on all the trial melts. For a period during one melt, highly oxidising conditions were produced in the cupola and over 50 per cent of the phosphorus in the metal was removed. The metal produced under these conditions was, however, unsuitable for further processing. When conditions were not unduly oxidising, phosphorus removal did not take place to any marked degree. The cupola slags were found to contain P_2O_5 in amounts sufficient to account for the whole of the phosphorus removed from the metal.

The experiments confirm that the stabilised dolomite material is satisfactory as a lining for a cupola and that stabilised dolomite cement is a satisfactory patching material. With carefully controlled conditions of operation, dephosphorisation of low-phosphorus metal during cupola melting is shown to be possible. The Sub-Committee is of the opinion that further experimental work might result in the development of a commercial process, and, in view of the importance of this matter to the industry, hope that arrangements for further work may be made.

Discussion

Dr. W. C. Newell (British Iron and Steel Research Association) said he had reviewed the two reports extremely critically, with the object of seeing how best the work could be continued and of directing the discussion to the future application of the work.

His general impression was that there was more information in the reports than had been truly digested in the text and in the summarising of conclusions. There had been insufficient consideration of the effect of temperature, and much of the information could have been clarified had temperature measurements been made in a more satisfactory manner. There had been rather full consideration of the previous work by Heiken, but the conclusion drawn by Heiken, that the carbon content was higher with the basic lining as compared with the acid lining, was not substantiated in the first report whereas in the work discussed in the second report it was found that a higher carbon content was obtained with the basic lining as compared with the acid lining. Dr. Newell suggested that that might be explained by a temperature effect.

It was necessary to keep in mind the prime object of the work, and that was not too clear. Were they trying to obtain low-sulphur or low-phosphorus material, or greater and more efficient refractory life? It was not clear whether statements made in the first report were observations or whether they were recommendations as to what should be done. For instance, it was stated that the basic lining should have a thickness of 9in and should extend from the bottom of the shell to a height of at least 4ft 6in above the tuyeres, and so on. It would not appear, however, that the work had proceeded far

† The Institute of British Foundrymen, Preprint No. 858, June, 1946.

enough to enable such generalisations to be drawn.

The suggestion to use chemical bonds was very fruitful. It might well be taken up in future work, and they might examine the use of bonds for basic linings, which might give improved properties.

Mr. L. W. Bolton said that Dr. Newell had put his finger on a weakness in the report, which was well known to the Sub-Committee, and that was in regard to temperature. But the work was carried out under commercial conditions in a works, and because of that the highly scientific aids available to investigators in research associations were not available in that particular case. It would be extremely difficult to explore the temperatures at which the reactions took place inside the cupola, though he did not say that it could not be done.

He believed it was stated in the report that the main interest in the work on basic linings would be to obtain linings having longer life and which were more refractory. In his experience the erosion of an acid lining when melting ferro-manganese for eight or ten hours a day was very serious. The slag produced was highly basic. He believed it was only in such cases that a basic lining would be used simply to obtain increased refractoriness.

Stabilised Dolomite

Mr. E. J. Brown, speaking as a steelmaker having extensive experience of the basic cupola with the use of magnesite for melting ferro-manganese, said that owing to the war the supply of Austrian magnesite had disappeared, and he had turned to the use of stabilised dolomite. In the early days of the use of stabilised dolomite it was found that it had two serious objections. One was its rapid dehydration, and, secondly, it had attacked the men's hands, so that they had almost had to give up its use. The use of ½ per cent oil, however, as a waterproofing agent, not only lengthened its life, but also eliminated the attack on the hands. It also afforded the opportunity to improve the ramming properties of the material, the desire for which had been mentioned by the Sub-Committee.

He did not think the steelmaker needed any method of dephosphorising. The basic arc furnace filled the gap quite nicely, and afforded a relatively simple and efficient method of desulphurising.

Dr. T. P. Colclough (Iron and Steel Board), referring to the dfference in carbon content of the metal when using a basic lining as compared with an ordinary ganister lining, suggested that the explanation was perfectly simple. The absorption of carbon by melted scrap was a function of time and temperature in the presence of carbon. In the experiments discussed in the first report, where the continuous tapping spout was used, the metal was taken away as quickly as it was melted, so that there was no appreciable pick-up. But at the Stanton Gate foundry, where the experiments described in the second report were conducted, 65 cwt. of melted metal were required at intervals of 10 min. So the cupola well was designed especially to store 3 tons of metal, with the result that the liquid slag was in contact with the coke for at least 10 min. In normal practice the carbon absorption was between 2·8 and 3·2 per cent. In the experiments the amount of coke in the bed approached 6 tons, with which the 3 tons of metal was coming into contact, so that there was the maximum opportunity for the absorption of carbon. Again, with a basic lining the temperatures were extremely high, approaching blast-furnace conditions.

Whilst appreciating that the experiments were made under wartime conditions in two or three places and as a spare-time job, Dr. Colclough said it was a pity that three problems were mixed together, and he urged that they be separated. First, the problem of the basic lining for a cupola was a very definite one, and should be tackled as such. Secondly, there was no question, as demonstrated by the work already done, that the basic lining of a cupola would permit a greater degree of desulphurisation than occurred in the ordinary cupola. But in so doing it was necessary to operate with a basic slag, and at higher temperatures, which meant higher coke consumption; and under present conditions the quantities of coke used and the cost of coke were fundamental factors. He urged that desulphurisation should be effected outside the cupola. To use more lime and fluorspar and more coke by desulphurising in the cupola did not appear to be right.

Thirdly, dephosphorising seemed to him rather akin to trying to paint something black when one wanted it white. Desulphurisation required reducing conditions, and dephosphorisation required oxidation conditions. The most important reaction was that between carbon and P_2O_5. The reason there was dephosphorisation in the experiments covered in the first report was that equilibrium was not approached; there was dynamic operation. Above the tuyeres there could be oxidation; the metal carried down iron oxide with it.

Mr. Bolton still felt that the problem of carbon pick-up was not solved satisfactorily. In the automobile industry, he said, there were many cupolas producing metal hotter than was ever produced from the Stanton Gate cupola. The charges had relatively high carbon contents, and they were melted at a higher temperature than at Stanton Gate, but if they ever tapped metal with a carbon content of 3·8 per cent there would be trouble. A quantity of 5 tons of metal would be held in the cupola well. Temperature was not the only consideration.

Mr. J. L. Harrison (Calton and Co., Ltd.), speaking from the point of view of the side-blown converter user, said they had tried a lining of basic material—stabilised dolomite in the form of bricks—and the results were most interesting, but not very promising from their point of view. They had tried to produce metal in the cupola which would be suitable for ultimate conversion in the converter, and they had achieved quite a large degree of desulphurisation and dephosphorisation. The phosphorus was reduced to the region of 0·01–0·02 per cent with a low silicon content; the temperatures were 1285–1380 deg. (immersion readings). The carbon content was increased by 0·3–0·5 per cent, and he rather agreed with the view that it was due to carbon pick-up in the cupola well. In normal acid practice among converter users a number of foundries had increased the depth of the cupola well to achieve carbon pick-up. One firm, which had been operating with a receiver and had had carbon contents of 2·8 per cent, had dispensed with the receiver in order to get higher carbon contents, up to 3·2 and 3·4 per cent.

One problem he had not been able to solve was the extremely low melting rate in the basic cupola, round about half, and in one case less than half that of the normal melting rate in the acid lined cupola.

Emphasising the importance of the cost of basic linings, he said that for the experiment the cost of material and labour to line the cupola was about £220, and they had got something like 10 tons of metal out of it, with very great difficulty. That might be an extreme case, but basic refractories were very much more expensive than the acid refractories.

Mr. Bolton said the temperatures quoted by Mr. Harrison were rather lower than those given by the Committee, and the Committee had obtained some extremely low phosphorus figures. He felt that the problem of temperature must be investigated if progress were to be made.

His own experience when he had first tried to use a basic-lined cupola, like that of Mr. Harrison, was that the melting rate in the early stages of the blow was only half that obtained when the furnace was ganister-lined, and it was found to be due to the inability to produce a fluid slag. As soon as the flux charge was modified, so that a fluid slag was obtained, the melting rate returned to normal.

The cost of the basic lining material was undoubtedly higher than that of acid material. The basic process could only be economic if they could derive benefits from the treatment which could not be derived in any other way, and he felt there was still a very good possibility that improvements in basic refractories would result in much more economic operation.

Patching

Mr. H. Parnham (General Refractories, Ltd.) suggested that, due to the high cost of basic refractory materials and the high cost of labour, there was need to get away from the age-old custom of patching; the idea of patching daily was rather nauseating, especially when the materials cost a lot. Stabilised dolomite was probably not the best for that particular job, and there was need to try to cover the field of magnesite and other types of refractories.

Patching was necessary, both in rammed linings and in fired bricks; even with hard-fired vitrified bricks there was a certain amount of erosion which needed to be made good every day. The flaking of rammed linings was most important and he believed most of the wear was due to mechanical rather than chemical action. The purpose of using chemical bonds was to increase strength. There was greater depth of penetration, and probably greater depth of flaking, which would increase rather than reduce costs. In general there was a need for a very abrasion-resistant non-spalling brick, preferably of the magnesite type, which was volume stable. He suggested that the hot zone should be made so that the 4½in brick could be used, and that it should be run for the day without patching. As soon as it had gone, it should be taken out, because, in view of the cost of labour and raw materials, it was almost as costly to patch as to put in a new one.

Mr. Bolton said that one foundry had overcome the difficulty by using water cooling in the melting and superheating zones of the cupola. It was then possible to use a refractory wash over the steel plates, and patching became a thing of the past. The difficulty with the system was that 100 per cent steel charge could not be melted, because the steel did not pick up carbon until it was fairly low in the cupola, and molten metal was deposited on the plates, which would build up gradually and would eventually stop the cupola. That did not happen to the same extent when pig iron was melted,

and the system was operated successfully with pig iron mixtures.

The system of using bricks and replacing them when worn he had seen operated in a foundry situated 500 or 600 miles from the source of refractories supply and they had maintained that it was the most economical method of operating a cupola. They had actually used in an acid cupola silica bricks, 4½in thick, which had lasted for a complete day's melt under extremely severe conditions, melting metal for whiteheart malleable castings at very high temperatures. It was their considered opinion that the most economical method was to replace the lining after each melt in the hot zone of the cupola.

The last portion of a thin lining would last for a considerable time; the lining was cooled to some extent by radiation, and the last inch lasted considerably longer than the third inch, due to the greater heat losses.

(To be continued)

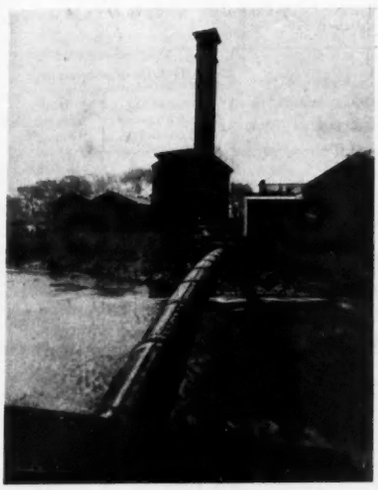
Flooding of Lea Bridge Station

ON March 15th the Lea Bridge pumping station in Lea Bridge Road, Leyton, London, was flooded by the rising waters of the River Lea. This station was constructed in 1852 and for many years has been relied upon to provide a supply of approximately 45 million gallons of water a day to the eastern and north-eastern portions of the Metropolitan Water Board's area. The River Lea runs through the western portion of the works, and down the centre there is an aqueduct conveying stored water from the King George and Walthamstow group of reservoirs to the filter beds at these works. The flood water flowed over the flood banks into the aqueduct and thence into the works, which became completely swamped at about 5.30 a.m. to depths varying from 1ft to 3ft. Some flood water also gained direct access over the flood banks surrounding the works. Thus, for the first time in their history, these works were put out of action, depriving approximately 1¼ million people of their normal water supply, a population greater than that of the city of Birmingham. It was obvious from the beginning that unless alternative supplies could be immediately given to the affected area, the local authorities would be faced with a problem of wholesale temporary evacuation.

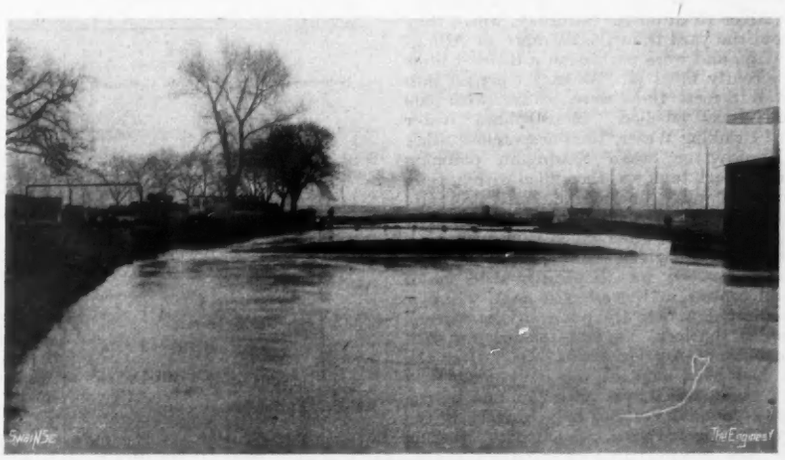
It was estimated that it would be at least a fortnight before the works were again fully in action; it would be necessary after the floods had subsided to pump out the filter beds through the culverts, clean the filter beds, and fill them with heavily chlorinated water, which, in its turn, would have to be pumped out before fresh water could be put in and the filtered water sampled to ascertain whether the water was up to the required standard for pumping into supply. In addition, much of the machinery would require cleaning; the electric motors driving the pumps to the Woodford zone had been submerged, and would have to be removed and completely dried out. It was fortunate, therefore, that the floods subsided sufficiently on the following day for preparations to be made for repairing the damage; pumping out operations were well under way on the Monday morning.

In the meantime, in view of the fact that the flood waters came along the aqueduct, a dam was constructed across this channel where it enters the works. In order to prevent water banked up by this dam from spreading laterally into the station, the existing flood-bank parallel to Lea Bridge Road was raised with sandbags filled with clay, and other points strengthened, with the assistance of 500 men of the Coldstream and Scots Guards. The wisdom of the decision to take these precautions was evidenced by the fact that on the evening of Tuesday, March 18th, the water on the upstream side of the dam was about 3ft above that on the downstream side and the works would otherwise have again been flooded.

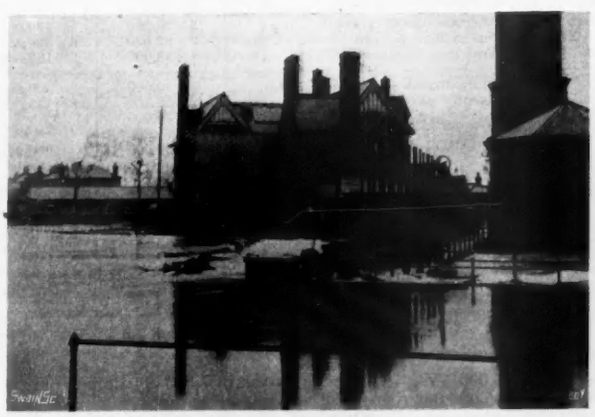
Early on Saturday morning steps were taken for the provision of alternative supplies, by means of two entirely separate operations. One was the transfer of more water from other areas into the district, and the other an organisation for the distribution of water by mobile tanks. It was found possible to increase the supply of water from the Hampton group of works, *viâ* Southern area, through the Tower and Woolwich tunnels, to approximately 15 to 18 million gallons a day. This water was only available, however, in the lower portions of the area nearer the River Thames. Water was also enfused from the west. The South Essex Water Company



VICTORIA ENGINE HOUSE BEFORE FLOOD



VICTORIA ENGINE HOUSE IN FLOOD



FULLY DRAWN SLUICES

MOBILE WATER TANK

offered a bulk supply of approximately two m.g.p.d. through the interconnections of its mains in the Ilford area, and a small supply was obtained from the Herts and Essex Water Company, and later on about four m.g.d. from the Sutton Water Company. In addition, the Croydon undertaking made arrangements to reduce its bulk supply from the Board by over one m.g.d. There remained, however, a very large population estimated at between 300,000 and 350,000, a population greater than that of the city of Hull, for whom the only supply would be by distribution from mobile tanks.

The wartime scheme for emergency supplies had been discontinued and all but a few of the 500 gallon tanks, numbering one thousand in all, had been sold; fortunately, approximately 332 of these had not been collected by the purchasers. Further tanks were obtained from water undertakings in the Greater London area, and also from provincial undertakings as far away as Leeds, Sheffield, Barnsley and Bradford. In addition, tanker wagons were supplied by local, Army and Air Force authorities. Transport was speedily obtained from the Board's cartage contractors and through the Ministry of Transport, so that by 9.30 on Saturday morning, mobile tanks were already available.

All lorries were instructed to report to the New River Head on the Saturday, where they entered the yard from the entrance in Arlington Way, and were parked on a disused filter bed recently filled in. As they emerged into Amwell Street, they were loaded with 500 gallon tanks labelled "Metropolitan Water Board Drinking Water," and despatched either to Hornsey or Stoke Newington pumping station. Each tank was then filled with heavily chlorinated water, and allowed an appropriate contact period in order to sterilise it as effectively as possible, after which it was emptied, cleaned out and given its first fill of drinking water. The lorry was then directed to one of several centres in the affected area, where it was allotted a delivery point in the streets, at which the local residents queued up with their buckets, kettles, baths, &c. After the tank had been emptied the lorry went to a filling point which was either at one of the Board's pumping stations or a hydrant in the nearest unaffected area, refilled with drinking water, and returned to continue the distribution, announcing its presence by means of a rattle. Special lorries were detailed for supplying hospitals, bakeries, restaurants, and other essential services, while a number of the mobile tanks were kept at Woodford each night to answer emergency calls. The whole of the organisation is under the control of the chief engineer and his staff, who worked early morning and late at night in order to get the organisation into being and to keep it running. Senior engineers tour the district continuously to detect and correct any flaws in the arrangements which might arise from time to time.

As soon as the Lea Bridge Works were flooded it was realised that the flood waters had entered the filter water wells and the under-drains of the filter beds, and that there might also have been leakage prior to the shutting down of the pumps. It was possible, therefore, that unpurified water had been pumped into the mains in the affected area, and immediate steps were essential to reduce the risks of spreading water-borne diseases. At noon on Saturday, at the request of the Board, the British Broadcasting Corporation broadcast a warning to the public in the affected area to boil all water being used for drinking or cooking purposes, and this warning was repeated half-hourly throughout the afternoon. In addition, police cars toured the district, repeating the warning from amplifiers and arranged with cinemas to flash similar warnings periodically on the screens.

A meeting was held on Wednesday, March 19th, between the Board's Director of Water Examination, the Chief Engineer, the Chief Medical Officer of the Ministry of Health, and the Medical Officers of Health of the affected districts, when the situation was explained and further precautions for the health of the public were discussed, while the Medical Department of the Ministry of Health was kept informed of the position from the outset.

It is too early to say when Lea Bridge Station will be fully in action again, but it is hoped that certain sections may be brought into service next week.

During the war, the Board learned that their staff were always ready to make any sacrifice of their leisure hours that was necessary to maintain the supply to the public; they would like to place on record that once again water consumers, in this case, the east part of London, have been saved from the serious consequences of a complete water famine only by the keenness, ingenuity and sheer hard work on the part of all the staff concerned.

Generating Plant Extensions

THE Central Electricity Board made arrangements with authorised undertakers during 1946 for additions, as detailed in the accompanying table, to be made to the generating capacity of the selected stations associated with the grid.

List of Generating Plant and Boilers for which Arrangements Were Made by the Central Electricity Board with Authorised Undertakers During 1946

Scheme area.	Name of station.	Owners.	Details of extensions. Generating plant number and capacity.	Boilers, number and capacity.
			kw.	Lb. per hour.
Scotland	Clyde's Mill	Clyde Valley E.P. Co.	2×30,000	4×180,000
	Portobello	Edinburgh Corporation	1×60,000	1×540,000
	Braehead	Glasgow Corporation	1×50,000	2×300,000
North-East England	—	—	—	—
North-West England and North Wales	Bromborough	Birkenhead Corporation	2×50,000	4×300,000
	Whitebirk	Blackburn Corporation	1×40,000	3×150,000
	Carrington	Manchester Corporation	2×57,000	4×360,000
			2× 3,000*	
	Agecroft	Salford Corporation	(a) 2×50,000	4×315,000
			2× 2,500*	
	Hartshead	Stalybridge, Hyde, Mossley and Dukinfield T. and E. Board	1×30,000	1×150,000
			1× 1,500*	
	Westwood	Wigan Corporation	3×30,000	4×300,000
Mid-East England	Grimsby	Grimsby Corporation	—	2× 80,000
	Skelton Grange	Leeds Corporation	3×60,000	6×360,000
	Prince of Wales	Rotherham Corporation	(b) 1×50,000	2×200,000
			1×30,000	2×200,000
	Thornhill	Yorkshire E.P. Co.	1×45,000	2×180,000
Central England	Staythorpe	Derbyshire and Nottinghamshire E.P. Co.	3×60,000	9×240,000
	Walsall	West Midlands Joint Electricity Authority	2×30,000	4×150,000
South-East and East England	Brighton	Brighton Corporation	3×52,500	6×320,000
	Bankside	City of London E.L. Co.	2×50,000	4×300,000
	Barking	County of London E.S. Co.	3×75,000	6×405,000
	Beddington	Croydon Corporation	1×50,000	2×320,000
			1× 2,500*	
	Cliff Quay	Ipswich Corporation	1×45,000	2×365,000
	Rye House	Northmet Power Co.	2×30,000	2×350,000
			2× 2,000*	
	Peterborough	Peterborough Corporation	2×20,000	3×160,000
	Brunswick Wharf	Poplar Metropolitan Borough Council	3×52,500	6×320,000
	West Ham	West Ham Corporation	1×30,000	2×180,000
South-West England and South Wales	Poole	Bournemouth and Poole E.S. Co.	3×50,000	6×300,000
	Carmarthen Bay	Llanelly and District E.S. Co.	2×52,500	8×175,000
	Plymouth	Plymouth Corporation	2×30,000	3×320,000
			2× 1,500*	
	Llynfi	South Wales E.P. Co.	2×30,000	2×300,000
(a) Cancelling a previous direction for :— 2×50,000-kW sets and 4×300,000 lb per hour boilers			−130,000	−1,400,000
(b) Cancelling a previous direction for :— 1×30,000-kW set and 1×200,000 lb per hour boiler				
Net additional plant for which arrangements were made			2,321,000	27,540,000

* Auxiliary sets.

These additions will aggregate 2,321,000 kW, involving an expenditure of about £100,000,000 and including provision for the first sections of eight new generating stations, Carrington, Westwood, Skelton Grange, Staythorpe, Rye House, Brunswick Wharf, Poole, Carmarthen Bay. The arrangements cover the greater part of the plant for installation under the programme of extensions for 1950, and complete the provision for the new plant due, under earlier programmes, for commissioning by the winters of 1948 and 1949.

Shipbuilding in Canada

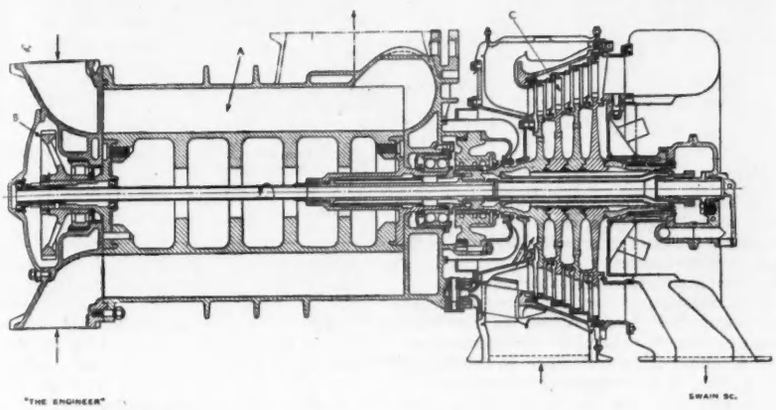
CONTRACTS have been completed for the construction in Canada of 45,733,000 dollars' worth of shipping for the French Government in the next two years. Six building yards in the provinces of Quebec, Ontario and British Columbia will construct thirteen cargo vessels and 140 barges under the contracts. Most of the tonnage is to be completed by the close of St. Lawrence River navigation in 1947, with five of the cargo ships to be delivered in 1948. The largest contract has been placed with Canadian Vickers, Ltd., of Montreal. This company will build four single-screw motor-driven cargo vessels, each of 5500 long tons deadweight. Each will cost 2,350,000 dollars. A contract awarded the Davie Shipbuilding and Repairing Company, Lauzon, Quebec, calls for three single-screw motor-driven cargo vessels, each 5500 long tons, less main engine, engine spares and three diesel generators with spares. Contract price is 1,725,000 dollars a vessel, and all are to be completed by the end of the 1947 navigation season. Six additional motor cargo vessels, each 2600 metric tons deadweight, will be built by Marine Industries, Ltd., Sorel, Quebec, at a cost of 1,393,000 dollars per vessel. Fifteen self-propelled hopper barges will be built by the Canadian Shipbuilding and Engineering Company, Collingwood, Ontario, at a total contract price of 6,360,000 dollars. The Dominion Bridge Company, Montreal, has been awarded a 3,228,000 dollars contract for construction of twenty self-propelled Rhine barges. In British Columbia twenty-five other self-propelled Rhine barges will be constructed by the Victoria Depot Machinery Company, Ltd., at a contract price of 2,587,000 dollars.

A Contribution to the Solution of the Gas Turbine Problem*

By A. J. R. LYSHOLM, M.I. Mech. E.†

No. II—(*Continued from page 241, March 21st*)

In 1936 a preliminary scheme was worked out for an exhaust turbine to be used on an internal combustion engine. Provided turbine and compressor efficiencies are high, a considerable power surplus will be available, especially at high altitudes. It was then proposed to utilise that power to give a reactive force, or to drive an auxiliary propeller. Such a unit, comprising a Lysholm compressor and a six-stage reaction turbine, laid out for low centrifugal stresses, was built for the Swedish Air Force, and successfully tested in a plane type P7, N17002, in July and August, 1942, behind a "Pegasus 24" engine.



A Compressor. B Synchronising gear. C Four-stage reaction turbine.

FIG. 6—*Exhaust Turbine for the Swedish Air Force*

The range of the tests were:—Altitude, 3000–20,000ft; maximum pressure before engine, 28–40in of mercury; and speed of turbine, 2700–8800 r.p.m. Additional units of a slightly modified design for the Pratt and Whitney "Twin Wasp" engine were ordered, but owing to war conditions and the introduction of the jet further development was cancelled before these units had been completed. Fig. 6 shows a section through this turbine, which had a weight of 220 lb. If it had been designed as a jet engine the static thrust would have been about 250 lb.

Owing to the versatility of the gas turbine a system of characterising the cycles proved very useful. For that reason symbols for describing the different cycles were introduced in 1935. For instance, the symbol 2–1–80 means two turbine expansions with one reheat, one intercooler and 80 per cent regenerator efficiency.

It was found to be very convenient to plot efficiencies, work ratio‡ and power factor§ over the compression ratio in a semi-logarithmic diagram. A more recent diagram (Fig. 7), by the author (1930), gives an idea how efficiency, work ratio and power factor for 650 deg. Cent. (1200 deg. Fah.) temperature and pressure ratios between 2 and 240 vary for cycles from 1–0–0 to 5–4–η_R. The basis for this diagram is 80 per cent turbine and 83 per cent compressor efficiencies.

It is evident that a high power factor is very valuable for large gas turbines, since it reduces the air flow for a given output. Thus a high temperature and a large number of reheats should be used for maximum power turbines. To reduce temperature in the low-pressure turbine, the reheat temperature should be lower or the heat drop larger for this turbine. The limiting factor will then be the size of the exhaust area; for a machine of 3000 r.p.m. this could probably be about 1·5 square metre. This gives, according to Fig. 7, approximate outputs for a temperature of 650 deg. Cent. as set out in the table overleaf.

The single-expansion turbine would hardly be used for very high outputs and thus an air flow of 300–500 lb per second has to be handled by the compressor to give power of 60,000–100,000 kW. This flow could possibly be taken care of by a single-pass dynamic compressor, but it would hardly be practical to use only one positive displacement compressor. It could, however, be delivered by eight Lysholm compressors double the physical size of the type of 12,500 cubic feet per minute running at about 2000 r.p.m. Preferably these compressors should be gear driven from a common turbine.

The Elliott-Lysholm Turbine

In 1942 the U.S. Navy's Bureau of Ships ordered from the Elliott Company, Jeannette, Pa., a marine gas turbine designed from preliminary lay-outs that had been worked out by the company with the author's collaboration. The fundamental basis of the design was that the thermal efficiency should be about 30 per cent at full load, and that it should have good part-load efficiency and satisfactory manœuvring characteristics, as well as light weight and compactness.

To meet these requirements the "2–1–75" cycle was adopted, and conical-flow reaction turbines and Lysholm compressors were used. With materials available at that time the stresses in the turbine were restricted to 7500 lb per square inch, corresponding to an expected life of 100,000 hours' running continuously at 1200 deg. Fah. and maximum speed. These operating conditions required a large number of stages in the turbine, even though conical-flow turbines were used. When planning the gas turbine, the use of only two turbines in series was tried, both turbines driving compressors with the output being taken out from one of the turbines, as previously referred to. Mr. R. B. Smith, of the Elliott Company, then proposed to change the arrangement in such a way that the low-pressure compressor should be driven by the high-pressure turbine, and the high-pressure compressor by the low-pressure turbine, the low-pressure turbine at the same time delivering useful power. The calculations showed that this arrangement was superior, and it was adopted for the actual plant. A full description of this plant has been published in 1943, 1945 and 1946 in the U.S.A. and therefore only a short summary will be given.

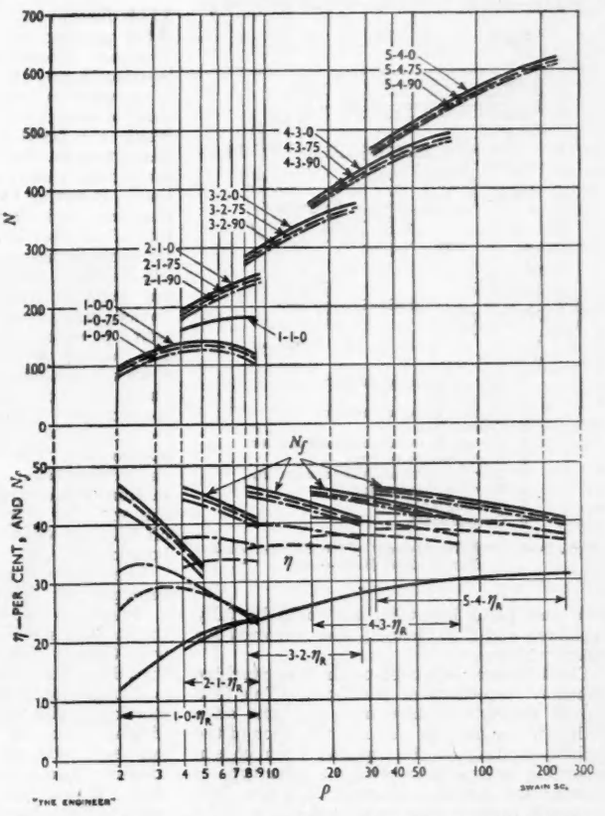
The turbine rotors were welded from a number of discs and two shaft ends in order to avoid large forgings, which are very difficult to produce from a good heat-resisting material. Turbine casings and diaphragms were supported by radial pins to give a heat-elastic construction. All compressors were of the Lysholm type having equal rotor dimensions, and the plant included one high-pressure and two low-pressure compressors in parallel.

The general arrangement is shown in Fig. 8. The total weight of the plant corresponds to about 30 lb per s.h.p.

The turbine is very easy to handle, as all manœuvring is done from a control panel, either directly by means of aeroplane type hydraulic levers or electrically by means of push buttons. On the panel all necessary temperature, pressure and speed control instruments—starting control, as well as warning lights for oil pressure, speed and temperature—are arranged. The injection pumps are of the intermittent Bosch type with eight plungers. When the load is increased suddenly a temporary increase in temperature of, at the most, 100 deg. Fah. is obtained, but very shortly the temperature is again stabilised. The short temperature increase has no bad effect on the life of the turbines.

The turbine is started in the following way: at first the low-pressure turbine and the high-pressure compressor by-passes are opened and the low-pressure compressor and high-pressure turbine unit is started by means of a starting motor of 50 h.p. capacity; the high-pressure burner is then ignited, the speed increased to 900 r.p.m. and the temperature gradually brought up to 1000 deg. Fah.

The total warming-up period is generally 2·5



——— η_R = 0 per cent. – – – η_R = 75 per cent. —·—·— η_R = 90 per cent.

FIG. 7—*Efficiency, Work Ratio and Power Factor*

* Abstract. Institution of Mechanical Engineers, March 14, 1947.

† Consulting engineer and chief engineer, A. B. Ljungströms Angturbin, 1928–44.

‡ Ratio between usable output and total power developed by the turbine.

§ Amount of usable output developed by the turbine per unit of air flow.

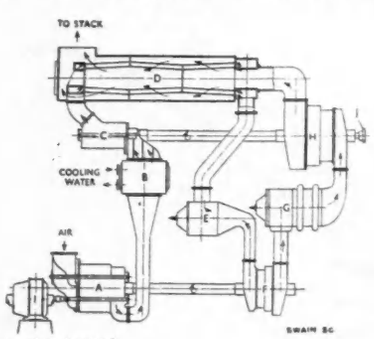
to 3 hours and this long period is necessary because the rotor heats up slower than the casing, causing differential axial expansions. Furthermore, the stresses caused by temperature differences are reduced. This warming-up time will be greatly decreased by suitable changes in design in the later turbines.

It is now possible to increase the fuel supply and close the by-pass valves, the starting motor being cut out automatically by means of a free wheel. The engine is now ready to be loaded instantaneously.

The turbine was started for the first time on October 28, 1944, and after some minor adjustments the acceptance tests were run on December 28th of the same year. During 1945 the turbine had been used to try out different details and gain experience for the three units of 3000 h.p. ordered by the U.S. Navy and the Maritime Commission after the acceptance tests. The total running time until the end of 1945 is 500 hours, including a non-stop run of 48 hours.

At the acceptance tests a thermal efficiency of 29·4 per cent was obtained at 2400 h.p., corresponding to a fuel consumption of 0·47 lb per s.h.p. Before the tests an efficiency of 31·5 per cent had been computed, using a turbine efficiency of 87·5 per cent and a compressor efficiency of 82·5 per cent. The difference—about 7 per cent—is not very large for a new plant like this, but could be fully explained and it is thought also corrected for future turbines.

Cycle	1–0–η_R		3–2–η_R		5–4–η_R	
Gas through low-pressure output turbine, per cent	32	100	50	100	50	100
Leaving velocity, feet per second	330	330	500	500	500	500
Kilowatts	8,700	27,000	30,000	60,000	50,000	100,000
Power factor, h.p. per pound per second	60	60	160	160	270	270
Air flow, pound per second	190	600	250	500	250	500



A Low-pressure compressor.
B Intercooler.
C High-pressure compressor.
D Regenerator.
E High-pressure combustion chamber.
F High-pressure turbine.
G Low-pressure combustion chamber.
H Low-pressure turbine.
I Starting motor.
J Output shaft.

FIG. 8—*General Arrangement of the Elliott-Lysholm Marine Gas Turbine*

The difference depended on the lower turbine efficiency, especially at part load. This is a typical example of how new problems arise with new designs. In this case the pitch of the turbine blading at the tip had been chosen according to experience with a similar type of blading for steam turbines. However, the Reynolds number was considerably lower for this turbine, and this caused separation and thus increased losses. For this same reason the pressure ahead of the high-pressure turbine dropped, which decreased the work done in the high-pressure turbine. The combined effect was nearly disastrous at low load, as it increased the gas temperature of the turbine considerably. Cascade tests with the turbine blades verified this experience, and for future designs separation can be avoided. An unexpected loss occurred when the carbon sealing rings seized and had to be replaced by labyrinths. For the new turbines this loss has been avoided by another design.

The difference also depended on the fact that the compressor efficiency came out lower than had been indicated by the tests with the experimental compressor. Its cause was that the inlet to the compressor had been made different from that of the experimental compressor, which resulted in high induction losses. This has also been rectified in the new designs. The regenerator, which was of the squirrel-cage type, came up to expectations, and it is rather interesting to compare the actual parasitic losses with the predicted. A comparison is shown in the table herewith.

Parasitic Losses in B.Th.U. per Pound

	Predicted.		Actual.
	1935.	1942.	4/4 load.
Duct work	0·9	0·8	0·44
Intercooler	0·36	0·37	0·45
High-pressure combustion chamber	0·54	0·54	0·31–0·52
Low-pressure combustion chamber	0·54	0·56	0·41
Regenerator, 75 per cent efficiency	0·9	1·1	0·86

The combustion is very good, but a certain stratification has been noticed at the high-pressure combustion chamber outlet corresponding to a temperature difference not exceeding 150 deg. Fah. The temperature distribution in the low-pressure chamber is, however, very good. No trouble has been caused by the stratification, but experiments are going on to even out the temperature. One serious difficulty occurred in the low-pressure compressor. It was caused by warping of the compressor casing, due to an air pocket in the cooling jacket. This was rectified and the compressor repaired.

At first the noise level was very disturbing, but this has been gradually improved upon, and it is now so low that the turbine can be run in the shop without any complaints. For the turbines under construction precautions have been taken to reduce the noise level further.

These turbines are of a slightly modified design, but made of another material which permits an increase in temperature to 1400 deg. Fah. It is hoped that it will be possible at a later date to publish details of these turbines, and other new developments, especially in the aeroplane field.

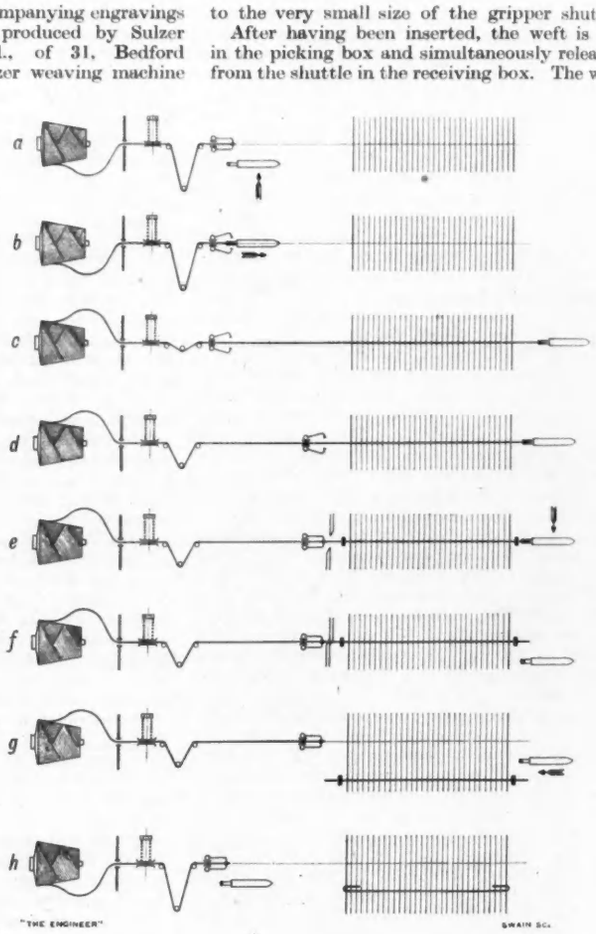
Bobbinless Weaving Machine

WE illustrate in the accompanying engravings a weaving machine produced by Sulzer Brothers (London), Ltd., of 31, Bedford Square, W.C.1. The Sulzer weaving machine is a pirnless shuttle loom of new design, in which the problem of weft insertion has been tackled on entirely new lines. Referring to the diagrams and illustration of the shuttles, the principle is that a very small shuttle, having at one end a gripping device, which holds the weft, is shot through the shed by means of a spring picking mechanism operated by a torsion rod. The gripper shuttle always inserts the weft from the left-hand side of the machine (see diagrams), the weft being pulled off a large cross-wound bobbin.

The shuttle races through the shed in a rake-like guide, so that neither shuttle nor weft touches the warp threads. The shuttle is brought back to its starting position in a picking box, on the left-hand side of the machine, by a conveyor chain underneath the warp. The shuttle is now ready to insert a further weft. A machine operates with many shuttles, so that independently of the specifically high number of picks, the speed of the returning shuttles is relatively small.

The warp let-off and take-up motions are the same as in standard looms. The shed, however, is only 2in to 2¼in high. This is possible owing to the very small size of the gripper shuttle.

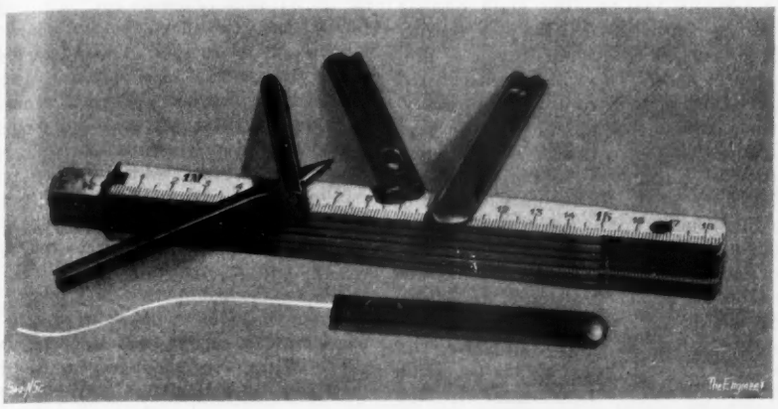
After having been inserted, the weft is cut in the picking box and simultaneously released from the shuttle in the receiving box. The weft in the shed, after having been beaten up, has both its ends slightly protruding. These ends are folded back in the next shed by a special



DIAGRAMS OF INSERTION OF WEFT THREAD

mechanism, so as to build a strong selvage. Another solution consists in fastening both ends by means of a complete twist, the selvage thus formed being similar to the leno selvage and only a fraction of an inch wide.

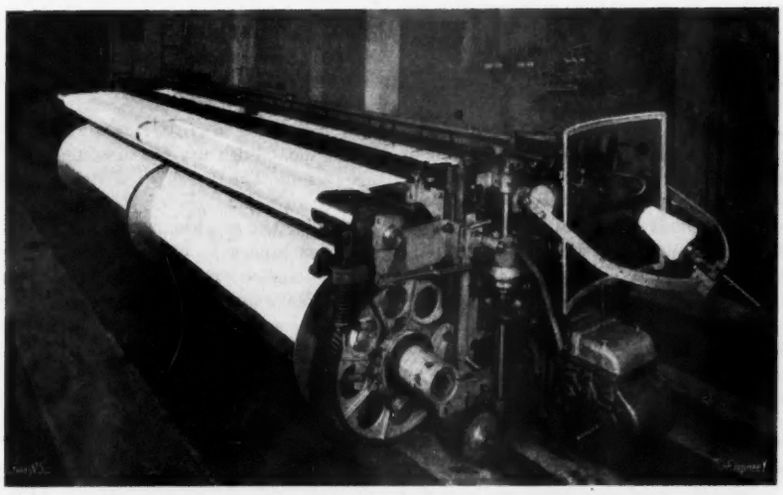
The working principle and the design of the trial weaving shed were erected at Oberwinterthur, Switzerland. Weaving trials on an industrial basis can be carried out there with commercial size weaving machines built, for the time being, on a tool-room basis. The results obtained are, we understand, constantly being



SHUTTLE COMPONENTS

machine also allow for exceptionally large weaving widths (up to 150in). It is therefore possible to weave either very wide fabrics or separate strips of fabric of the same or different widths side by side. For this purpose special intermediate selvaging devices were developed so that the intermediate selvages may also be formed in the manner described above.

Owing to its design the new weaving machine is claimed to have the following advantages :— As the pirns are replaced by large cross-wound bobbins (chesse), weighing up to 4 lb, rewinding and equipment costs are considerably reduced. The small dimensions and low weight of the shuttle permit considerably higher picking speeds for 80in reedspace, according to the weaving width and the material woven. The slay and harness motion being relatively small, the strain, especially that on the warp, is



WARP AND PICKING SIDE OF WEAVING MACHINE

reduced correspondingly. The running of the machine is economical, since one or more fabrics of different widths can be woven side by side. This feature, combined with the high number of picks per minute, results in high production per machine. The specific space and power requirements are also small. The weaving width can be easily and rapidly adjusted. Since the machine has no superstructure, the operator has a good view and attendance is facilitated.

The Sulzer weaving machine can also be fitted with a weft-mixing device.

A few years ago assembly workshops and a turned to account and data collected for the further development of the machine.

The machine illustrated in our engraving is the TW8 model, with a weaving width of 150in.

The Professional Engineers' Appointments Bureau

THE Professional Engineers' Appointments Bureau, which, it will be recalled, invites applications for registration for employment from members who, by reason of their engineering qualifications, belong to the Institution of Civil Engineers, the Institution of Mechanical Engineers or the Institution of Electrical Engineers, or persons whose engineering qualifications for election or admission to one of those bodies have been approved by the respective councils, recently issued the following report of its activities in 1946, its first full year of operation. The address of the Bureau is 13, Victoria Street, Westminster, S.W.1.

During 1946 the average number of engineers on the register was 964, of whom 184 were primarily civil, 390 mechanical and 390 electrical engineers. Employers have supported the Bureau well by notifying 1155 vacancies during the year, a number of the applications being for more than one engineer. In general, nominations have been made within seven days of the vacancy being notified. It is known that at least 217 engineers have obtained posts with the employers to whom they were nominated by the Bureau. This figure is above the estimate of the results anticipated for the Bureau's first year of operation, but actual results may well be higher, as information has not yet been obtained on a number of the nominations made, despite the operation of a "follow-up" system, the necessity for which has increased the pressure on the Bureau's small staff of four. It is also known that at least a further 158 engineers were offered posts, as a result of the Bureau's introductions at or above the minimum salaries they specified, but the positions were not accepted for various reasons, the most usual being the lack of suitable living accommodation. These figures do not, of course, include the numerous engineers who have registered but have either decided to stay with their present employers after testing the market or have decided, on the Bureau's advice, to return to their pre-war employers.

Except under special circumstances it has been the policy of the Bureau to refrain from putting engineers forward for posts carrying salaries below the minimum figures shown on their application forms. In the early part of the year it was noticeable that a large proportion of engineers on the register were specifying minimum salaries considerably in excess of those offered by employers notifying vacancies, but in the latter part matters have improved appreciably in this respect. The salaries at which posts have been filled range up to £2000 per annum and the age of the candidates placed up to sixty-five. Considerable difficulty has, however, been found in placing engineers over forty years of age; though, where possible, the Bureau has tried to influence employers not to specify low maximum age limits. An age analysis of engineers on the register has indicated that approximately 40 per cent were under thirty, 35 per cent between thirty and forty, and 25 per cent over forty. A corresponding analysis of the age of the engineers who have been placed shows that 50 per cent were under thirty, 40 per cent between thirty and forty and 10 per cent over forty; 52 per cent of the engineers placed were ex-Servicemen.

Extensive use has been made of the advisory services of the Bureau both by registered engineers and employers, and judging from the replies received this function of the Bureau has been widely appreciated. Whilst a large number of engineers on the register have indicated they are anxious to obtain employment in the Dominions, the majority of the overseas vacancies notified have been for the Middle and Far East or Central and West Africa, and difficulty has been experienced in finding candidates who appear willing to go to those countries.

Registration and appointment fees received during the year totalled £478 and £1025 respectively. Further donations amounting to £1238 were also received due to the generosity of employers' organisations, firms and members of the three institutions. The sum of £264, which had to be withdrawn from the capital originally subscribed, to cover the balance of the cost of operating the Bureau, is less than was anticipated.

INTERNATIONAL TELECOMMUNICATIONS CONFERENCES.—The United Kingdom Government has accepted an invitation from the United States Government to send delegations to attend the following International conferences, which are to be held at Atlantic City during the coming summer: An International Radiocommunication Conference, to open on May 15th, for the purpose of revising the International Radiocommunication Regulations, including the allocation of the radio frequency spectrum between the various types of wireless service; an International High-Frequency Broadcasting Conference, to be held immediately following the International Radiocommunication Conference, for the purpose of securing a better regulation of long-distance broadcasting services, and a Plenipotentiary Conference of the International Telecommunication Union, which will begin on July 1st, for the purpose of drawing up a new International Telecommunication Convention to replace that signed at Madrid in 1932, and framing statutes under which the International Telecommunication Union will enter into relations with the United Nations Organisation.

THE ENGINEER

MARCH 28, 1947

VOL. CLXXXIII No. 4757

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

For Subscription Rates, see page 2 of Advertisements.

DEATH

ON March 22nd, Mr. ANDREW MILLER ALEXANDER, M.Inst.C.E., M.I.N.A., aged 92.

PROFESSIONAL ENGINEERS APPOINTMENTS BUREAU

IT was in November, 1945, that the Professional Engineers Appointments Bureau, set up, as an independent body, by the Institutions of Civil, Mechanical and Electrical Engineers, first started to operate. On another page of this issue we publish a statement about its work during 1946. Though, naturally, as it is a new body, its operations during the year were on a comparatively small scale, the results have provided a number of points of interest. For instance, it is clear from the figures given that the old and saddening problem of finding employment for those over forty years of age—a problem that became particularly acute between the wars—still exists. About 25 per cent of applicants to the Bureau during the year were over forty years of age, but of the total of those who found employment only 10 per cent were in that age group. The fact that over one third of all applicants known to have been offered employment as a result of the activity of the Bureau did not take it up is primarily to be traced to difficulties of finding suitable accommodation, a reflection of the effect of the housing shortage upon employment. The further note that whilst overseas vacancies were found to predominate in the Middle and Far East and in Central and West Africa, applicants preferred to seek employment in the Dominions may well foreshadow a future problem in finding suitable technical personnel for the less popular areas of the Commonwealth.

But, however provocative of reflection such statistics may be, the main interest of the statement necessarily lies in its bearing upon the conditions of employment of professional engineers. It will be remembered that certain contributors to our correspondence columns at the turn of the year took objection under the heading "Remuneration of Engineers" to the practice of certain firms when advertising vacancies of including such words as "state salary required" or "salary according to age and experience." No doubt that objection was rooted in the applicants' lack of knowledge of the salaries their attainments could really command, combined with a suspicion that employers hoped by such means to obtain their services at favourable rates. In fact, we believe it to be more likely—the experience of the Bureau supports our view—that it is a matter of mere habit, though a few employers may sometimes be in as much doubt as to how much they should pay for an engineer's services as the applicant is as to how much he should ask. The employer then hopes, by the use of the form of words of which complaint is made, to test the market. By resolving the doubts of both parties on such a point the Bureau undoubtedly performs a very useful service. For, while it calls upon the applicant to state the minimum salary required, it also endeavours to persuade employers that when notifying a vacancy they should specify, if not a precise salary, at least the range within which the salary offered will be "according to age and experience." Moreover, since it is the Bureau's general practice "to refrain from putting engineers forward for posts carrying salaries below the minimum figures on their application forms," both parties, employers and prospective employees, are encouraged to place their salary offers or demands at reasonable levels. For if on the one hand an employer offers too little, the Bureau will be unable to satisfy fully his requirements in the technical ability and experience of the applicants placed in touch with him; whilst, on the other, the applicant asking too much will receive few introductions. Upon questions being then asked, the Bureau has available in its records the evidence to prove, without revealing names of firms or of applicants, what level of salary should be offered or asked as a reasonable figure for the job or jobs concerned. That service acted in both directions during the year. For, during the war, many engineers obtained employment carrying salaries at a level wholly uncommercial for civil life, and were, naturally, disinclined at first to accept a reduction, whilst many employers needed convincing that post-war salaries must be higher than those ruling before the war. The Bureau unquestionably performed a valuable service during the year by helping to stabilise salaries on a new post-war basis reasonably satisfactory to both parties.

But though the work of the Bureau has clearly been valuable, and though its success so far has exceeded the expectations of the controlling Board, its operations, no doubt, will have given little satisfaction to those, of whom there were several amongst the contributors to our correspondence columns, who believe that the status of engineers can only be raised by first improving the level of salaries. For, in effect, the Bureau has done no more than equate the salaries offered to salaries asked at a level settled by the law of supply and demand. Yet the influence even of that limited achievement upon raising the status of engineers should not be underestimated. As a result of the advice given by the Bureau to one employer, for example, that the salaries offered for certain posts were too low to attract the type of engineer desired, and of the convincing evidence with which that advice was backed up the whole salary structure of that concern was reviewed with considerable benefit to its engineering staff. Thus, the Bureau, quite automatically, by acting as a market in which salaries can find their commercial level, is already influencing those employers whose estimate of the value of engineers in the past has been too low. When the Bureau becomes more firmly established as one of the more important means of introducing professional engineers to employers it must equally automatically attain a position of greater power. Whether it should in such circumstances go further and formulate from time to time for itself scales of salaries that should be held in bad times as well as good will then become debatable. It is, in fact, possible that it is already under consideration. But it is clearly too soon yet to act upon any conclusion that may be reached. The first objects of the Bureau must be to attain a nation-wide reputation for service and to become self-supporting.

THE L.M.S. DIESELS

Two aspects show prominently in the programme for main line diesel locomotives just announced by the largest British railway, and mentioned in greater detail elsewhere in this issue. Both are worth some little consideration. The first is the obvious care taken to get an exact idea of the power requirements for the services proposed, and to provide machinery to give it. For the heavy Anglo-Scottish trains, which load normally up to 500 tons or more, the new twin-unit diesel locomotive is to have installed engine power of 3200 b.h.p. Assuming 80 per cent efficiency through the electric transmission—a most ample figure, taking the operating range as a whole—the rail h.p. is 2560, or, say, 2500 h.p., allowing for some of the auxiliary load. Now, according to one of the most reputable of the many formulæ for locomotive horsepower under British conditions, the maximum normal output at the rail of the L.M.S. "Pacifics" is 2400–2500 h.p.

The parallel is close enough to obviate, on the one hand, complaints that the diesel is grossly overpowered and the comparison not fair to steam; on the other hand, there can be no grouse from diesel advocates that the chief mechanical engineer has lent his weight to the steam side. The same consideration applies to this main line diesel locomotive when run as two separate 1600 b.h.p. units, but not so much to the 800 b.h.p.

branch line locomotive. The stated parallels are between the 1600 b.h.p. diesel and one of the big 2–6–4 T steam locomotives, and between the 800 b.h.p. diesel and one of the new 2–6–2 T engines. The top rail h.p. of the 2–6–4 T is of the order of 1300, compared with about 1275 for the diesel; but the latest 2–6–2 T engines should give about 850 r.h.p. as a short-time maximum, whereas the corresponding diesel locomotive could never give more than about 670 r.h.p. But though the official comparison with the 1600 b.h.p. diesel unit is the 2–6–4 T, the actual capacity will be much more akin to that of the standard class "5" 4–6–0. If a 2–6–4 T comparison is right for the 1600 b.h.p. diesel, then two 2–6–4 T steam engines do not correspond with a "Pacific." Any power : weight comparison of the 1600 b.h.p. diesel with the 2–6–4 T needs substantial adjustment to allow for the cruising range, for though the weight of the steam engine is probably only about 155 lb per nominal maximum r.h.p. its range without refuelling can be scarcely half that of the diesel. A truer comparison —with the class "5" engine—would show a better power : weight ratio for something like equal range between refuelling; and the general speed-power characteristics also are more like those which the class "5" engines exhibit in a wide variety of services—from London–Leicester to Perth–Inverness turns.

The second aspect to which attention may be drawn is that the design of large diesel-electric locomotives has not advanced very greatly during the last eight years. A weight of 110 tons for 1600 b.h.p., even for a high-speed locomotive which needs more consideration as a vehicle than a mixed-traffic or slow-speed unit, is by no means low, and corresponds to a specific weight of 154 lb per b.h.p. As long ago as 1938 diesel locomotives of 4400 b.h.p. were successfully operating on express services at a weight of 115 lb per b.h.p., a difference that cannot be attributed so much to high total power as to high output from a single engine-generator group. Moreover, modern American diesel locomotives with an enormous amount of electrical and ancillary equipment and an engine weighing 20 lb per b.h.p. and running at the same order of speed as those in the L.M.S. locomotives, weigh only about 120 lb per b.h.p., though operating long-distance 60–70 m.p.h. services. Unless single engines of 2500–3000 b.h.p. at 750 r.p.m. or faster, and of not more than 20 lb per b.h.p., become practicable, the gas turbine may well take the floor from under the large diesel locomotive without the latter ever having shown its potentialities in Great Britain.

Obituary

SIR JOHN WATSON GIBSON

It is with deep regret that we have to record the death in London on Wednesday, March 19th, of Sir John Watson Gibson, a director of Pauling and Co., Ltd., civil engineering contractors, and during 1943–44 Deputy Director-General of Civil Engineering (Special) at the Ministry of Supply. He was born in 1885 at Middlesbrough, and was the son of Mr. R. E. Gibson, of Linthorpe, Middlesbrough. After completing his education at the Middlesbrough Grammar School in 1900, he became a pupil with Sir John Scott, on the construction of the Middlesbrough dock and remained with Sir John until 1908. He then joined the first Lord Cowdray's firm, S. Pearson and Son, Ltd., with which he gained valuable experience in civil engineering contracting work in various parts of the world. Work upon which he was engaged included the construction of the King George Dock, Hull; Queen Mary Reservoir, Staines; and irrigation works on the Blue Nile in the Sudan. In 1925 Mr. Gibson was the agent in charge of the construction of the Sennar dam. During the first World War, from 1914 to 1918, Mr. Gibson was Director of Shell and Gun Production in the United States of America, took part in a Special Mission to India, and was Controller of Aircraft Requirements and Review at the Air Ministry. Between the two wars he took charge of several civil engineering contracting works, including the canalisation of the Gezira, and from 1933 to 1937 the construction of the Gebel Aulia dam over the White Nile. This work was carried out by Pauling and Co., Ltd., under the style of Gibson and Pauling (Foreign) Ltd. In both Egypt and the Sudan he will long be remembered. As a result of the partnership mentioned above, Mr. Gibson was invited to join the Board of Pauling and Co., Ltd., in January, 1937.

It was only natural that a man with such a talented personality and skill in contracting work should be called to Government office during a time of war. In 1940 and 1941 he was responsible for the construction of the Royal Ordnance Factories, and in 1942 became Technical Adviser to the Board of Trade, and he initiated the open-cast system of coal working, which brought into the task of coal winning many civil engineering contracting firms.

From 1943 to 1944 he served under Sir Andrew Duncan at the Ministry of Supply, and did much valuable work, which culminated in his direction of constructing the Phoenix breakwater units for the Mulberry Harbour used at Arromanches. It was in recognition of his successful leadership in that enterprise that a knighthood was conferred upon him in 1945.

As soon as the war was over he turned to problems of reconstruction and development, and lent his energies unstintingly to the complexities of housing through British Steel Houses, Ltd., in its steel house programme. Only quite recently, we may recall, Sir John Gibson and his firm, Pauling and Co., Ltd., were chosen to undertake the civil engineering works connected with the ground nut scheme in East Africa.

ALEXANDER ARCHIE JUDE

Steam engineers will learn with regret of the death of Mr. Alexander Archie Jude, which took place at the Queen Elizabeth Hospital, Birmingham, on Saturday, March 8th, in his seventy-first year. For many years he was chief turbine designer to Belliss and Morcom, Ltd., of Ledsam Street Works, Birmingham. Mr. Jude was born in the City of Norwich in 1875, and he received his early education at King Edward VI School, Norwich. After completing his technical education in general engineering subjects, he was apprenticed to Earle's Shipbuilding and Engineering Company, of Hull. He began to serve his six years' apprenticeship course in 1890 and in 1893 he was successful in gaining a Whitworth Exhibition. On completing his apprenticeship in 1896 he stayed with the firm for a further five years in the drawing-office.

He moved to Birmingham in 1901 to join the firm of Belliss and Morcom, L'd, and was employed as a leading draughtsman on the design and development of the firm's larger types of triple-expansion steam engines. Alongside this work Mr. Jude undertook for the firm research into the design and construction of a steam turbine, and in 1904 the first Belliss and Morcom experimental turbine was run. From 1904 onwards he took complete charge of the design and development of Belliss and Morcom steam turbines. As his designs show, he was a man of considerable inventive ability. Among his many achievements in turbine construction was the design of the first 10,000-kW Belliss and Morcom turbine running at 3000 r.p.m., which was supplied to the West Ham Corporation power station. About 1906 Mr. Jude published a treatise on the theory of the steam turbine, in which much of his early work and experience is embodied. To-day his treatise is still looked upon as an outstanding work in the early steam turbine literature. He was a member of the Institution of Mechanical Engineers, the Institute of Metals and the Birmingham Metallurgical Society.

JOHN NATHANIEL JORDON

The death of Mr. John Nathaniel Jordon, the managing director of Massey Harris, Ltd., of London and Manchester, which took place in a nursing home in Manchester on Thursday, March 20th, will be widely regretted among agricultural engineers. Mr. Jordon, who died suddenly and unexpectedly after a long illness, from which he seemed to be recovering, was looked upon in this country as a leading authority on agricultural implements and their operation in the field.

He was born at Ben Lomond, New Brunswick, in Canada, in 1885, and he joined the Massey Harris Company in Canada in 1905, at its Maritime Provinces Branch at Moncton. Six years later he was transferred to Saskatoon as a repair man, and working his way through the various departments he became superintendent of agencies and manager of the Saskatoon branch. In 1928 he moved to Toronto to assist in the managerial work of the Ontario branch.

In 1930 he was chosen to come to London to the Massey Harris office in Bunhill Row, to take over the general managership of the Massey Harris organisation in Great Britain from Mr. Charles William Dawkins. That position he continued to hold with distinction, and when manufacturing in this country was begun recently he was appointed managing director of Massey Harris, Ltd., Manchester.

In taking over in Great Britain Mr. Jordon encountered the difficult slump years, but his powers of leadership and his energy of purpose throughout the troubled period resulted in a continued increase in Massey Harris activities in Great Britain, which culminated in the firm acquiring for manufacturing purposes a leading Government shadow factory in Manchester.

He fostered the introduction into this

country of such notable agricultural machines as the combined grain and fertilizer drill, the wide tractor drill and the combined harvester.

During the critical war years of 1939 to 1945 Mr. Jordon was responsible for the importation from Canada of large quantities of farm machinery and spare parts for use on British farms, and he played no small part in our food growing campaign.

After the war he organised the taking over and replanning of the new factory at Manchester, already referred to. In spite of many difficulties he had the satisfaction of seeing production begun within thirteen months of the decision to take over the factory.

He was a valued member of the Canadian Chamber of Commerce, served on the Council of the Chamber for many years, and was a Vice-President. A lifelong member of the Agricultural Engineers' Association of London, he served on many of its committees.

Although Canadian born, Mr. Jordon, who lived in Britain for seventeen years, grew to know and appreciate British agricultural methods and business principles and to love the English life. He made many business and private friends, and his death at a comparatively early age, at the zenith of his powers, will be deeply mourned.

The Institution of Naval Architects

No. I

THE Institution of Naval Architects opened its annual general meeting in the Hall of the Royal United Service Institution, Whitehall, London, S.W.1, on Wednesday, March 26th, under the Presidency of Admiral of the Fleet Lord Chatfield. The President welcomed the members and then called on the secretary to present the report of the Council.

Report and Accounts

The council's annual report and accounts for the year 1946 were adopted, the hon. treasurer expressing the view that owing to increasing expenditure, it would be necessary to consider increasing the subscription to the Institution, which he said had not been increased throughout its history.

Presentation of Premiums

The premium awarded to Mr. F. B. Bull for his paper, "Structural Investigations in Still Water on the Welded Tanker 'Neverita' —Part I. Developments in Instruments for Measurement of Strains and Deflections in Ship Structures," was presented by the President.

Monsieur R. S. Guilloton, who has also been awarded a premium for his paper, "Further Notes on the Theoretical Calculation of Wave Profiles and of the Resistance of Hulls," was unable to come over from France, and the President said it would be sent to Monsieur Guilloton, with the good wishes of the meeting.

The President then delivered his address, from which we print the following extracts:—

President's Address

The past year has been one of great activity in our shipyards. We can well be proud of their achievements in 1946. The tonnage under construction at the end of the year was very close to 2,000,000 gross tons, while the actual completions in the same year equalled about 1,000,000 gross tons. You will have been interested to read the reference to shipbuilding in the Government's Economic Survey for 1947. The Government has set a "target" of 1¼ million gross tons for 1947, in addition to a large repair programme. But the White Paper points out that the achievement of that "target" depends upon increased output per man-year and upon adequate supplies of materials, fittings and other components. The latter matter is an important one, for it is admitted that it will not be in this year, or even next, that we shall see adequate supplies of all the things we need for ship construction. Shortages will continue, and therefore the problem of priorities will still be with us. It is comforting to all who have the interests of the shipbuilding and marine engineering industries at heart (and who realise the extent to which our whole national economy depends upon them) to see the emphasis laid on them in this Economic Survey. Are we at last seeing evidence of a change, long sought for in the years gone by—a general realisation of the place of shipbuilding and marine engineering in the scheme of things? If, in a condition of continuing shortages, importance is attached to achieving a higher output from the shipyards in 1947 than in 1946 (when some of our present disabilities were less prominent), then the industry must be given a degree of priority not less than that accorded to housing and to the export trade in its narrower definition. I use the term "narrower definition" advisedly, because it is too often overlooked that the shipping industry is one of the greatest of all export industries—as the carrier of goods and the earner of foreign exchange for its services in all parts of the world. It has been often said that shipbuilding is the great "assembly" industry. It is important to remember that in relation to priority status in the national economy, because it means a first call on some proportion of the products of the majority of industries in the country.

In this connection one would wish to stress a feature of the greatest importance now and for the future (something the White Paper does not specifically mention), the absolute necessity for materials and supplies of all kinds being of the highest quality. It is in our maritime industries that there has been such justifiable pride in the past, in the superb quality of our products. We dare not lose sight of the value of that reputation in our struggles to re-establish ourselves. It is not enough for Britain to build ships—she must build the finest ships in the world, judged by every applicable standard.

At the present time British shipyards have under construction and on their order books a total of 3,300,000 gross tons, of which 878,000 gross tons (or 27 per cent) is for foreign account. The total value is estimated at approximately £250,000,000 and the foreign work represents approximately £70,000,000.

Added to these great activities of ship building and ship repairing, a large programme of ship reconstruction or reconversion has been carried through. As was pointed out by one or two speakers in the discussion on some of our papers last year, this business of radically altering ships from their original design into vessels capable of performing totally different functions can never be wholly satisfactory to the naval architect. Nevertheless, I have no doubt that those enormous tasks which war made necessary have taught us something and opened our eyes to conversion possibilities which we had never previously thought of as practical undertakings. As is to be expected after a war of such unprecedented complexity, we have several papers in our programme which once more reveal the ingenuity and skill with which some particularly difficult problems were successfully solved by naval architects and shipbuilders. In reading through those papers I have been impressed by the authors' constant reference to the help and co-operation they received from all sections of the shipping industry at all times. The picture conveyed is a heartening one and shows not only the extraordinary competence and resource of the private shipbuilding firms and their vital importance to this country, but their public spirit in working together for the national good; to pool knowledge and share out work, with a complete absence of that type of rivalry that might otherwise obstruct and hinder the rapid completion of an undertaking.

It is right, however, that as your President I should sound a note of warning. After the strenuous efforts of all during a long war it is natural that some feeling should exist among individuals that equally strenuous effort is not required when war has ended in complete victory. But we know now that modern war leaves both victor and vanquished exhausted, and we cannot afford to abandon to-day that spirit of patriotism with which we won the war.

What has this to do with shipbuilding and marine engineering? It is true that to-day that industry is busy and could employ more labour than is available. But there is a red light ahead and leaders in the industry must not shut their eyes to it if they are to avoid the grim conditions that prevailed in the industry shortly after the first World War. That red light is the present high cost of ships and the long time taken to build them. At one dreadful period in the years between the two recent wars ships were lying idle on the stocks, and men actively employed in shipbuilding were reduced to a mere fraction of the numbers that could have been employed. That was because shipowners could not pay the high prices then prevailing for ships.

God forbid that we should let history repeat itself. But the amber light is showing. Hampering controls and the dearth of certain materials and components are two causes of the troubles. Rising wages and the demand for shorter hours are another cause. Every patriot looks forward with hope to the time when real wages shall be higher and there shall be more leisure with wisdom and means to use that leisure to promote true happiness. But at present we are still fighting as truly as we were in 1939–45. We are fighting against a permanent lowering of the British standard of living. In the question of output per man-year lies the key to the success of our whole industrial effort to recreate the ravages of war, to re-establish ourselves in the markets of the world and to expand existing and capture new markets as the foundations of future prosperity.

I must add a few words on warship design and construction. The most notable event of the year has been the completion and commissioning of H.M.S. "Vanguard," designed by Sir Stanley Goodall, now in South African waters with Their Majesties. If we compare her with H.M.S. "Hood," completed at the end of the 1914–1918 war, we can get immediately an impression of the increased complications, resulting, in the

main, from the scientific advances made during the intervening years and accelerated during the war. All those devices which help to fight the ship and those necessary to meet the increased air menace have had to be carried and manned, and the increased complement to be accommodated. The "Vanguard" is an illustration of the way in which our naval constructors have tried to tackle those problems of whose existence I reminded you a year ago. Further than this the appearance of the ship gives, at a glance, the information that increased freeboard has been found necessary.

Just outside the more narrow field of naval construction, another notable event, the atom bomb tests at Bikini, has given our constructors and naval architects a whole host of new problems. I believe that H.M.S. "Vanguard" will be a truly historic ship, in that she will be the last super "Dreadnought" as we have known them. The Navy will always need capital ships, but the "Vanguard's" successors will be very different; of that I feel certain, though I am only your President, not a prophet! Let the nation remember, however, that so long as we are dependent on merchant ships to bring us food, materials and oil, ships of some type will be essential to protect them in war, of similar types to those of our opponents. Nothing will protect ships in the oceans from destruction by enemy warships except our own warships constantly in escort by day or night in all weather conditions. Our naval architects have got to face this problem of the modern warship with the imagination and ingenuity they have always shown, and by the utmost application of the science of the period.

The year has brought no new naval orders and many of the ships under construction a year ago, if not scrapped, have either been put on one side or are proceeding slowly; no doubt the new orders when they come will include some of the Bikini lessons as well as new weapons. The spectacular side of atomic power as exemplified at Bikini has captured the imagination of the world, but even more important to us as naval architects is the possibility, by no means remote, that atomic power will become available as a means of propulsion. Such a development may be farther off than just around the corner, but another new development, the gas turbine, is now on the threshold of practical application, and there is no doubt that this will have a powerful effect on the performance of ships of all kinds.

At our meetings during the year we have had a number of papers describing in some detail the great work carried out by our industry during the war. During these present meetings a few more leaves will be turned, and I hope that the greatest possible publicity will be given to these indications of how shipbuilders and naval architects helped our country in her time of need.

(To be continued)

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE COST OF INCENTIVES

SIR,—Mr. H. Migliori's letter, which appeared in THE ENGINEER for March 14th, refers in the main to a particular case where direct monetary incentives resulted in a marked increase in output and in earnings. Under proper conditions direct monetary incentives can lead to improved output, lower costs and higher earnings, but unless the conditions are right the application of such incentives is more likely to lead to labour troubles and high costs. The prerequisites for successful application of strong direct incentives are good supervision, properly adjusted base rates, good inspection, good production control and planning, good shop records, good time study and a proper approach to the worker—in a word, good management. Unfortunately, all firms do not measure up to these requirements as well as do some firms in the industry referred to by Mr. Migliori.

We must not lose sight of the fact that overall costs are what matter—it is not good enough merely to achieve improved output on certain direct labour operations or machines. One must be certain that such improved output justifies the cost of the incentive payments, of installing and administering the incentive scheme, of increased supervision and inspection and of the lieu bonus which will inevitably be demanded by workers on other operations where incentives may be impracticable. Let us have incentives by all means, but only if they result in lower overall costs.

With regard to Mr. Migliori's suggestion (which has recently been put forward from several other quarters) that overtime payments should be exempted from taxation, I must say that I think this would be a most dangerous and unsound move which would put a premium on inefficiency and increased costs. The idea of exempting bonus earnings from taxation is attractive, but would that not lead to an increased demand for lieu bonuses, which, presumably, would also have to be exempt from tax?

C. H. STARR.

London, March 20th.

THE QUALITIES OF INVENTIVENESS AND RESOURCEFULNESS IN ENGINEERS

SIR,—It is becoming increasingly recognised that the ability to pass examinations does not necessarily carry with it certain qualities required in industry. Those of inventiveness and resourcefulness are of enormous importance for instance, and of far greater value than a lot of theoretical knowledge, the owner of which has no idea how to apply. These vastly important attributes, which may be summed up in the word ingenuity, are so valuable to manufacturers generally, and the country in particular, that one would have thought that strenuous efforts would have been made to bring them to light by making it an important job of all examining bodies. These qualities, coupled with workshop skill of good standard, which they often include, and quite a moderate grade of theoretical knowledge, have taken famous engineers far in the past, and in the writer's long experience will do the same for engineers in the future. The trouble is that such people are not sought and may be lost to industry for years.

What apparently is required is that a portion of a qualifying examination, carrying high marking, if necessary, compensating for lack of marks in the higher theoretical directions, should be carefully worked out, as engineers of this type, whether on design, organisation or production, are by far the most valuable. It should not be impossible to work out the required tests based on engineering psychological principles, which surely, with all the knowledge we now possess, is not so terribly difficult. It would be interesting to have opinions of other engineers on the matter and perhaps those of the psychologists.

CHARLES BAXTER.

March 19th.

ATOM BOMBS AND POISON GAS

SIR,—I have just seen your leader in the January 3rd issue, in which you compare the atomic bomb with poison gas, though, as you admit, "rather desperately." From this comparison you deduce that perhaps as a last resort a solution to the problem of atomic energy control might be found in each country arming themselves with an agreed number of atomic bombs.

The operative word is "agreed." Any potential aggressor would, of course, manufacture additional bombs unless effective control is obtained; thus this is rather begging the question. Using the example of poison gas, which was not used by either side in the late war, is, I fear, a false analogy. Gas is ineffective if elementary precautions are taken, but may be partially effective in the first days of its use if good enough weather for large-scale distribution can be assured. It is essentially a weapon of surprise, and weapons of surprise must now offer a reasonable hope of completely paralysing the war potential of a country in a very short space of time. Gas does not offer such a hope, whereas atomic bombs do.

The only safe way of meeting the "atomic crisis" is by a change of heart resulting in a reduction of nationalism. If we delude ourselves with false hopes of an easy way out, we shall fail to make the necessary effort, and it is for this reason that I hope you will publish this letter.

G. F. C. ROGERS,
Lecturer in Mechanical Engineering.

Bristol University, March 18th.

LOCOMOTIVE VALVE GEARS

SIR,—As Mr. K. N. Harris suggests, it is desirable to avoid the appearance of pedantry in a technical discussion, but it is still more desirable to avoid inaccuracy.

"Automatic advance in valve timing" with approach to mid-gear, specially mentioned by Mr. Harris in connection with Stephenson gear, is also a characteristic of Walschaerts gear, but Mr. Harris seems to be uncertain on the point. The changes in the positions of the admission and compression points are smaller than with Stephenson gear, and that is why Walschaerts gear is inherently the more suitable for early cut-off working and why Stephenson gear must be given negative lead in full gear to avoid excessive compression at early cut-off. Negative lead is not "a particular form of valve setting designed to take advantage" of the Stephenson gear's large "automatic advance in valve timing," but is necessary to minimise the disadvantage of that feature.

When Stephenson gear is designed for efficient early cut-off working it must have negative lead in full gear. When Walschaerts gear is designed for early cut-off working it must not have negative lead in full gear. It seems fair to say, therefore, that negative lead in full gear is a characteristic of Stephenson valve gear as opposed to Walschaerts valve gear.

If one says that negative lead is not characteristic of Stephenson gear, inasmuch as it can be avoided if performance is disregarded, one may as well say, for example, that the circular form

is not characteristic of wheels because it would be possible to substitute a twenty-sided polygon, but surely there is no point in making comparisons between inefficient freaks.

W. A. TUPLIN.

Huddersfield, March 21st.

LOCOMOTIVE BOILER PRESSURE

SIR,—In his letter of December 28th, your correspondent, Mr. Arthur H. Graham, gives a table showing the saving in the weight of moving parts when roller bearings replace plain bearings. For example :——

	Plain Bearings	Roller Bearings
Crosshead assembly	754 lb	367 lb
Piston, piston rod and parts ...	765 lb	350 lb
Front end of main rods	422 lb	210 lb

Now the crosshead assembly and the front end of the main rod (presumably the connecting-rod) are interdependent, and the only bearing which exists is that for the gudgeon-pin. This pin may be fixed in the crosshead and free in the small end, or vice versa. If the former construction is used, there is only one bearing in the small end, *i.e.*, the small-end bush. With a gudgeon-pin fixed in the small-end there will be two bearings in the crosshead. In either case only one component requires bearings, yet a reduction in weight is claimed for both. It is difficult to understand how there can be any saving in weight in this application since the housing for the outer race—or races—of the bearing(s) can hardly be smaller than that required for plain bushes.

Again, in just what way can roller bearings be applied to "piston, piston-rod and parts." Where are the bearings in, or for, these components ?

Any further information which your correspondent can give will surely be of interest to many readers.

E. B. PARKER.

Cheshire, March 8th.

KING'S COLLEGE ENGINEERING SOCIETY CENTENARY

SIR,—The King's College Engineering Society are grateful to you for the full account you gave of their recent centenary celebrations.

In the abridgment of the centenary address by Professor Davies a statement appears that "At University College an Engineering School was established in 1828, . . ." This is a misinterpretation of the facts, which, as set out in the address, are : "On the foundation of that [University] College in 1828 it was desired to establish an Engineering School and Mr. J. Millington was appointed Professor of Engineering and the Application of Mechanical Philosophy to the Arts. However, he resigned his Chair before the College opened, but agreed to give occasional lectures. . . . The Chair of Civil Engineering was not established until 1841, the first holder being Professor C. B. Vignoles, a prominent railway engineer, who held the Chair until 1845."

This is in keeping with the later statement in your article : "Evidence shows that King's College, in addition to appointing the first engineer as an active professor, also had the first properly constituted engineering school in the United Kingdom."

REG. J. HARTLES,
President.

London, W.C.2, March 21st.

SNOW

SIR,—In his letter on this subject, Mr. B. W. Abbott does not seem to have appreciated that special precautions against the effects of heavy and prolonged snow are rarely (if ever) taken in this country only because serious snowfalls are of infrequent occurrence. In those countries which are snowbound every year many steps are taken which would normally be unnecessary here.

During the war I was stationed in the snow-belt in Southern Ontario, where I saw fences being erected in November along main roads. These fences are of the chestnut pailing type about 3½ft high ; they are erected about 25 yards from the road to prevent drifts. Their purpose is to make the snow form drifts on the windward side of the fence instead of on the roadway itself.

Much research has been carried out on the properties and behaviour of snow, and there are research establishments in most countries to which snow problems are indigenous. Perhaps the most celebrated of these establishments is that maintained by the Swiss Government ; I think it is connected with the University of Zürich, but my memory may be faulty about this.

If Mr. Abbott is anxious to go into this matter further, I could verify this point, and also perhaps amplify the very brief comments above.

J. R. W. MURLAND.

Belfast, March 17th.

Mercantile Shipbuilding for the Year 1946

THE statistics compiled by Lloyd's Register of Shipping of merchant vessels launched during the year 1946 are now issued, and they include records for the war years compiled from such information as has become available. Excluding ships of less than 100 tons gross, there were launched in the world 747 vessels of 2,127,421 tons gross, of which 1,133,245 tons were from berths in Great Britain and Ireland, and 994,176 tons abroad. The output in Great Britain and Ireland represents 53·3 per cent of the total. Among the principal shipbuilding countries abroad, the tonnage launched for registration under other flags was as follows :—United States of America, 20 vessels of 78,342 tons ; British Dominions, 14 of 37,542 tons ; Sweden, 11 of 28,622 tons ; and Italy, 5 of 2120 tons. The world launches for the year include 165 vessels of 6000 tons each and upwards, of which 14 range from 10,000 to 15,000 tons, and 7 are of 15,000 tons and upwards, 4 of the latter being built in Great Britain. The total tonnage of steamers launched in the world is 1,193,083, of which 590,770 tons, 49·5 per cent, were launched in Great Britain and Ireland, and 602,313 tons, 50·5 per cent, in countries abroad. There were launched 101 vessels of 737,979 tons to be fitted with geared steam turbines. There were also launched 6 vessels of 70,474 tons in which turbo-electric propulsion is employed. In addition, there were launched 30 vessels of 95,649 tons with a combination of steam reciprocating engines and low-pressure turbines. In Great Britain and Ireland there were launched 38 turbine vessels of 297,598 tons, including 4 of 38,474 tons fitted with electric drive, and 16 vessels of 68,193 tons with a combination of steam reciprocating engines and turbines. The total tonnage of motorships launched in the world is 921,619 tons. Of these, 529,756 tons, 57·5 per cent, were launched in Great Britain and Ireland and 391,863 tons, 42·5 per cent, in countries abroad. The motorships include 2 vessels, of 7660 tons, in which electric drive is employed. During 1946 there were launched 58 steam and motor oil tankers of 420,046 tons, excluding vessels of less than 1000 tons, of which 42 of 298,797 tons were built in Great Britain and Ireland. Of the 58 tankers, 37 of 264,544 tons are motorships. Of the steam tonnage launched in the world, 1,193,083 tons, about 1,050,000 tons are steamers fitted to burn oil fuel in their furnaces, so that of the world tonnage launched during 1946 approximately 6·8 per cent only is exclusively dependent on coal for propulsion. Of the merchant vessels launched in the world during 1946, 364 of 1,296,956 tons, 60·96 per cent, were built under the survey of the Society with a view to classification in Lloyd's Register Book. Of this total, 245 vessels of 953,306 tons, 84·12 per cent of the tonnage launched there, were built in Great Britain and Ireland ; while of the tonnage launched abroad, 119 of 343,650 tons, 34·57 per cent, were built under the inspection of Lloyd's Register.

F.B.I. Regional Research Conference

THE first of the regional conferences on industry and research, organised by the Federation of British Industries, was held at Birmingham on Tuesday last, March 25th. At the morning session the conference discussed the subject of "Research and Economic Recovery," and papers were presented by Sir William Larke on "The Significance of Industrial Research in Relation to the Country's Economic Position," and by Dr. J. W. Jenkin on "The Industrial Problems of the Midland Area and its Research Needs." The chairman at this session was Sir Ernest Canning, who said that the urgency of taking the offensive against our present economic difficulties was immediate, and that the efficiency of the prompt application of research to production was the touchstone of the value of scientific work for industry and the measure of the service which science could render to industry. At the afternoon session Sir Edward Appleton presided, and the conference discussed industrial research in the Midlands. Papers were read by Mr. F. G. W. King on "Midland Research Organisations, Activities and Facilities," and by Mr. J. G. Pearce on "The Smaller Midland Firm and its Application of Research." A summing up of the day's discussions by Sir Wallace Akers concluded the conference.

Flooded Agricultural Land

THE Minister of Agriculture, Mr. T. Williams, made a statement in the House of Commons on Monday last, regarding Government aid in connection with the recent extensive flooding of agricultural land. Laying special stress on the flooding in the Fens, the Minister said that the breaching of the banks of the Fen rivers and drainage channels, raised many feet above the level of the surrounding land, had assumed the character of a major disaster. The Ministry had placed all its resources at the disposal of catchment boards in the Fens and particularly in the Great Ouse area. Emergency pumping equipment had been assembled at a central point and would be available to the catchment boards. The special nature of the disaster in the Fens, Mr. Williams continued, justified special measures of Government aid, and it was proposed to offer to the catchment boards concerned, in respect of repair works on their embanked channels, grants at 20 per cent above the normal rate, subject to a maximum of 90 per cent of their expenditure. In respect of the clearance of internal drains and farm ditches in the areas which had been submerged by the waters as the result of breaches in flood embankments, the Ministry would be prepared to offer grants at the rate of 75 per cent, as compared with the normal rate of 50 per cent. The Minister said that works carried out by catchment boards and other drainage authorities, assisted by Government grants, had undoubtedly lessened the extent of the flooding in many areas. The carrying out of a number of major long-term improvement works had been, however, inevitably slowed down by the war. Such schemes were now being resumed and would receive prompt and sympathetic consideration by the Ministry. When approved, the schemes would attract substantial grants under the Land Drainage Act.

Industrial Applications of Electronic Techniques*

By H. A. THOMAS, D.Sc., M.I.E.E.

No. II—(*Continued from page 248, March 21st*)

Control Methods When Detecting Element Produces Electrical Output.—In many cases the output of the detecting element is electrical, usually taking the form of a d.c. voltage, often of very small magnitude. For industrial instrumentation a d.c. amplifier is required to operate a much less sensitive instrument than would be needed if the output from the detecting element were used directly. True d.c. amplifiers responsive up to very high frequencies are unsatisfactory for industrial application, owing to their liability to zero creep. Very high frequency response is not usually required, however, and in such cases various reliable methods of amplification are now available.

One method has been developed by Gall[17] and is illustrated in Fig. 7. The voltage to be amplified is applied to a reflecting galvanometer with a series resistor R. Light from a small lamp source is reflected from the galvanometer mirror on to a photo cell, the effective resistance of which controls the phase of the a.c. voltage supplied to the grid of a thyratron valve. The anode of this valve is supplied with an a.c. voltage and variation of the phase of the grid voltage varies the time during each cycle when the valve is conductive. The effective current output is thus governed by the degree of illumination of the photo cell. This output is fed

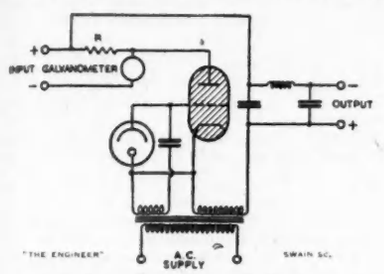

FIG. 7—*Gall d.c. Amplifier*

back through resistance R in a direction such that the voltage drop opposes the applied voltage. Stability is attained only when the fed-back voltage equals the applied voltage and when the galvanometer is undeflected. Since the output current is strictly proportional to the voltage across R it must also be strictly proportional to the input voltage. Consequently, a current meter in the output circuit can be made to read the small d.c. input voltage and it is linear over its whole range.

This feed-back principle has the great merit that variations in supply voltage or changes in the valve characteristic make practically no difference to the output current; consequently extreme sensitivity can be obtained in a remarkably simple manner. The method has been applied principally to the measurement and recording of temperature, but obviously it can equally well be used in any device involving small d.c. voltages.

An alternative method makes use of a mechanical chopper.[16] It has been used in a potentiometer pyrometer in which the generated e.m.f. is compared with a reference voltage derived from a d.c. potentiometer. The reference voltage is varied by movement of a contact along a slide wire, the balance condition being maintained continually by an automatic device.

Electronic Motor Control.—In many industrial applications the actuating control mechanism is either a motor or a device which is motor-operated, *e.g.*, rheostats, gas and steam valves, tapped switches, &c. In such cases means are required for controlling such motors from the small power (usually about 1 watt) delivered by valve amplifiers, which, in turn, are operated by the much smaller power sources associated with the detecting elements. The particular type of control best suited to any particular case is dependent primarily upon the power required to operate the motor, but is also dependent upon the time lag which is permissible between detection and correction of any change in the system. This factor also affects the overall stability of the controlling system.

One system of motor control[32] suitable for small power output is shown in Fig. 8. The two windings of an a.c. motor are both supplied from a common supply, the windings being so arranged that current in one produces rotation in one direction and current in the other rotation in the reverse direction. In series with each winding there is a transformer winding which, on open circuit, presents a sufficiently high impedance to reduce the current to a negligible value. The two valves associated with transformers T_1 and T_2 are normally biased beyond cut-off by the voltage *E*. If contact is made by switch C, so raising the grid potential of one valve, current flows in the associated transformer, the impedance presented in the corresponding a.c. winding is reduced, and the motor rotates in the direction determined by the position of the switch.

This circuit may be adapted for continuous control, and may be operated by a photo cell. It is claimed[32] that a 1-volt change in photo cell output changes the motor from full speed in one direction to full speed in the other direction.

Another control system suitable for larger motors[33] is illustrated in Fig. 9. Here the field

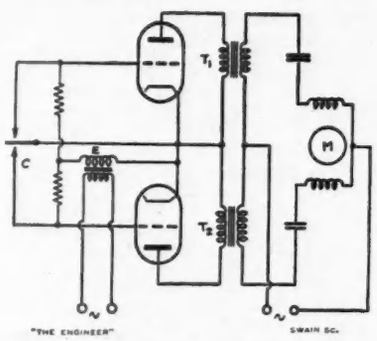

FIG. 8—*Ryder a.c. Motor-Control System*

is separately excited with d.c., which may be derived from an a.c. supply by suitable rectifiers. The armature is connected in series with two thyratrons as shown. Thyratron A will pass half waves of one polarity and thyratron B half waves of opposite polarity. This pulsating unidirectional current will cause motor rotation in one direction if A is conducting, and in the opposite direction if B is conducting. Point C is positive with respect to the cathode of either thyratron when its respective anode is positive. This positive potential can be applied to the grid of either thyratron by means of switch S, so producing rotation in the desired direction. Positive grid valves are used because then it is not necessary to provide a source of negative grid voltage to cut-off the valve. The a.c. voltage provided should be twice the rated voltage of the motor, since with half-wave rectification only 45 per cent of the voltage is effective.

Speed control can be obtained by addition of a variable choking coil in series with the switch. Variation of the inductance of this coil will produce a phase shift in the voltages applied to the grids of the thyratrons, and hence will produce a change in the main current supplied to the armature.

A very high degree of stability of motor speed can be achieved with circuits of the above type by controlling the d.c. to the phase-shifting inductor directly from the armature circuit.[37]

For very large motors, such as those used in rolling mills, large machine tools, presses, &c., the Amplidyne system of control[1, 12, 35] may be adopted. In this system the field of the main motor is excited by a special generator with an auxiliary short-circuited winding. The short-circuit current may be controlled by another winding carrying only one-hundredth of the short-circuit current, and this current, in turn, is only one-hundredth of the current provided across the main brushes. Thus a current gain of 10,000 : 1 is possible, and an imput of about 1 watt is capable of controlling a large motor. This small input can readily be obtained from a valve amplifier operated by any of the detecting devices previously mentioned

Production Aids

Introduction.—The control techniques and measuring devices briefly described in the preceding sections can be applied in a large number of ways as aids to production. Such devices can be arranged to give aural or visual indication when certain limits are exceeded or when a certain process is completed, and can be adapted to control automatically these limits or processes.

The limits can be established in terms of time, speed, position, temperature, pressure, humidity, size, shape, colour, noise, &c., or even in terms of chemical changes in the composition of a body. For example, in the control of products such as paints, dyes, inks, glues, &c., a device such as that shown in Fig. 3 can be used to compare continually the shade of colour of the product with a preset standard.[18] Such a device can be operated without fatigue by unskilled personnel and can differentiate shade to limits well beyond the capabilities of the human eye. Electronic methods can be

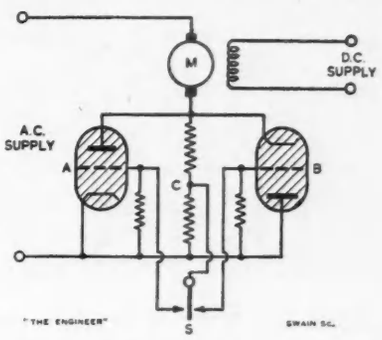

FIG. 9—*Ryder d.c. Motor-Control System*

employed in the production of photographic film to detect flaws and blemishes on the emulsion, and in the chemical industry for accurate titration, the manufacture of jams and jellies, the refining of sugar, and the sterilisation of food.

The correct application of such electronic methods may often lead to a greater production output per man-hour, and may effect very important improvements in the quality and consistency of the manufactured product. Applications can be found in almost every branch of industry. It is possible in this section merely to describe briefly a few known applications to illustrate the diversity of the devices at present in use and to suggest further applications.

Sequence and Timing Devices.—One important field of application lies in the control of machine tools, such as drills, lathes, shapers, presses, millers, &c. By use of trip switches mechanically or light operated by the work itself, switching sequences can be prearranged to perform repetition jobs in the minimum time without attention. By the addition of electronic timing circuits involving the discharge of capacitors, time delays between successive operations can be prearranged. In milling machine operation, for example, electronic control can be arranged to feed the milling cutter into the work at a preselected speed, automatically switch a few seconds later to another preselected speed, rapidly reverse the motor at the end of the operation by means of a limit switch, and shut down the machine on completion of the operating cycle.[37] Thyratron a.c. motor control may be adopted in the manner described above.

Another important application is the control of welding time.[47] In resistance welding the

* Abstract. Institution of Electrical Engineers, January 16, 1947.

two pieces of metal are held under pressure in intimate contact, the weld being made by passing a definite current through the joint for a definite time. The current used is very high, usually lying between 1000 and 100,000 amperes, and the resistance of the joint is very low. The leads from the points of application to the secondary of the welding transformer necessarily have an appreciable reactance, and consequently the power factor is low, usually about 0·5. In consequence, the control device must function over an appreciable range of power factor, and if the power supplied is to be definite in repetition work the timing control must function in terms of complete current cycles. For spot welding it is usual to adopt a current impulse adjustable from 1 to 30 cycles; for seam welding a series of impulses spaced by definite "off" times is required.[6] To obtain such precise timing, synchronous starting, *i.e.*, the switching-on of the circuit at the beginning of a current cycle, must be used.

For large powers control may be obtained by the use of mercury pool tubes with immersed starting electrodes.[29]

[Elaborating the principles of welding control, the author proceeded to describe a circuit for synchronous starting and control of welding current, using thyratron valves.]

Photo-Electric Cell Devices.—Applications of photo-electric cell devices to industrial production are more numerous than all the others. Interruption of a light beam may be made to operate intermittently a switch or motor con-

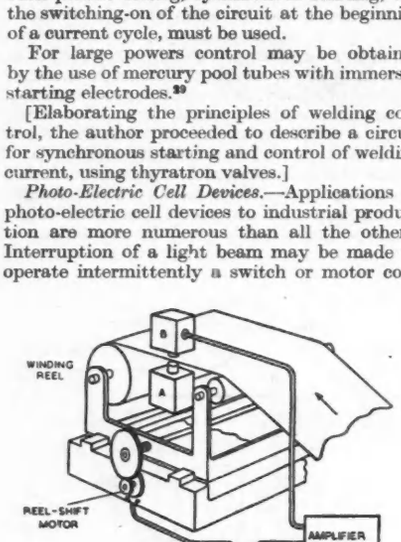

FIG. 10—*Reel Control in Winding Machinery*

trolling the process, or differential devices employing balanced cells may be arranged to give continuous control. Light beams may be employed in place of limit switches in many machine tool operations, parts being manufactured by a repetition tool may be counted, doors may be opened automatically, and protection to operatives may be provided—all by the use of photo cells.

One application to the winding of metal sheet or paper on drums[35] is illustrated in Fig. 10. Here a source of light A provides a narrow light beam which illuminates the photo cell B. The unit AB is arranged at the edge of the paper being reeled, so that any side shift during winding will either increase or decrease the cell illumination. The photo cell output is amplified and controls an Amplidyne generator, which, in turn, operates the reel-shift motor in such a manner as to correct the shift.

Registration in packing, printing and cutting machines can often be improved by applying photo cell devices.[15] In wrapping machinery the printed design has to be registered accurately on the sheet before it is presented to the wrapping device. To produce such individually printed sheets, paper manufacturers use either a flat-bed press which prints each sheet separately and is comparatively slow in operation, or a rotary press, printing paper in a continuous web. Owing to atmospheric changes particularly humidity, the roll of paper stock may have stretched or shrunk during the period between printing and wrapping. Furthermore, the means of feeding the web is usually a combination of metal, rubber or cork rolls that pull the web in jerks from the roll of stock and deliver it to the cutter. Such a feeding device may give rise to stretch, which must be recognised and corrected before cutting.

With intermittent feed this may be done automatically.[11]

[Here the author described a method for controlling registration to within $\frac{1}{32}$in, the intermittent feed being allowed to hunt between two limits of throw—one a little too great and the other a little too small.]

With a rotary cutter and continuous feed the problem of correct registration is more difficult. Here it is necessary to time the cutter so as to coincide with correct alignment of the printed web while the paper is in rapid motion. With an index spot $\frac{1}{16}$in wide and a paper speed of 100ft per minute each spot impulse lasts for only 1/320 sec.; the feeding speed must be controlled continuously by the impulses derived from the photo cell. This problem arises in a much more acute form with multi-colour printing, in which successive colour impressions need to be aligned on a printed web travelling at possibly 1000ft per minute.

Means of producing alignment accurate to about 0·002in have been developed[50] using printed register marks on the side of the web. The essential features of the device are shown in Fig. 11. On the side of the web is printed every few inches with the first impression a series of register marks, 0·01in wide and $\frac{1}{2}$in

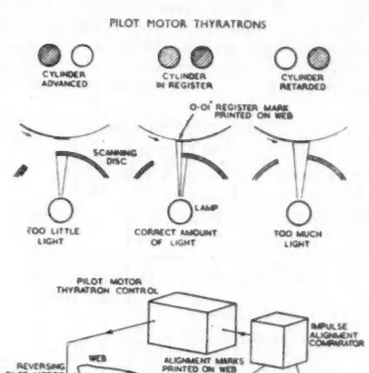

FIG. 11—*Photo-Electric Register Control*

long. As the web is driven in contact with the printing cylinder short pulses are produced by means of the photo cell and web-scanning head. Attached to the rotating cylinder is a scanning disc, scanning head and photo cell providing a second set of impulses. The two sets of impulses are compared; if alignment is correct the scanning disc cuts off sufficient light at the instant that the web-scanning circuit is operative to give no motion to a differential reversing motor. If the printing cylinder is retarded the light is cut off and the differential motor rotates so as to increase the speed of the feed, and if the printing cylinder is advanced the light intensity is increased and the differential motor rotates so as to reduce the effective speed of the feed. Such a device provides practically continuous alignment of the printed web with respect to the printing cylinder.

Photo cells have been applied for the automatic squaring-up of cloth in the final drying and stretching process, thus raising materially the textile finishing standard. Cloth straightness is defined as the perpendicular relationship between the weft and warp threads, and any deviation from the desired relationship is known as "skew." To correct skew during the stretching process it is necessary to apply forces to the side of the cloth as it is being reeled up. To do this automatically a skew detector is required which can operate a straightener motor for applying the necessary forces during the reeling-up process.

One form of skew detector[30] consists of two scanning light spots moving at the same rate over two straight lines at right angles to each other, both these lines being at an angle of 45 deg. to the motion of the cloth. If the light spots are smaller in width than the individual threads (about 0·003in) an impulse will be produced for each thread interception if a photo cell is fixed on the opposite side of the cloth to the light source. If the cloth is straight the number of impulses produced in each scanning detector per unit of time will be the same, but if it is skew the number of impulses produced in unit time will be different. The control circuit must compare the impulse rates from the two scanning detectors and operate the straightener motor when required in such a manner as to make the two detectors generate impulses at the same rate.[30]

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(To be continued)

Diesel-Electric Traction on the L.M.S.

It has just been announced that the London, Midland and Scottish Railway Company has decided to introduce diesel-electric traction to is main line services. Diesel-electric locomotives are being built for experimental use in main line passenger and freight services, including the more important express passenger trains on Anglo-Scottish services.

The first experimental locomotive will be for express passenger services and will be capable of hauling the heaviest trains between London and Glasgow, or fast light trains between these cities. The new type of locomotive will be able to work services comparable with the pre-war "Coronation Scot" train, which was normally worked by the company's most powerful 4–6–2 steam locomotive.

The new locomotive will be composed of two 1600 h.p. units coupled together, and the English Electric Company is providing sixteen-cylinder diesel engines of 1600 h.p., together with the electrical equipment for each unit. These diesel engines will be to the firm's own design, based on the engine used in the L.M.S. diesel-electric shunting locomotive. The L.M.S. is building the mechanical parts of both units in its Derby workshops. The weight of the locomotive will be 220 tons, and it will be capable of speeds of 100 m.p.h. A flexible gangway is being provided between the units so that the length of the locomotive can be

traversed for inspection purposes while running. It is proposed to put the first locomotive of this type into service between Euston and Glasgow, in competition with the 4–6–2 steam locomotives at present in use.

In a second experiment each of the two units which make up the express passenger locomotive will be used for separate work. These 1600 h.p. locomotives will be used for suburban and semi-fast passenger trains and medium-weight main line freight services, such as are now hauled by large 2–6–4 tank steam locomotives. Examples of the work which the new locomotive will undertake are the Outer London suburban passenger services to Bletchley and Luton, passenger and freight working on the North Stafford section round Stoke and in the Derby, Nottingham and Leicester areas.

The third experiment carried out by the company will be with an 800 h.p. diesel-electric locomotive suitable for branch and cross-country passenger and freight services, of comparable capacity with the company's small 2–6–2 tank steam locomotives. The sixteen-cylinder diesel engine, generator, traction motors and control gear for this locomotive will be provided by the British Thomson-Houston Company. The engine will be built by Davey, Paxman and Co., Ltd., as sub-contractors to B.T.H., and will be of a design developed by the sub-contractors for the Admiralty during the war.

In order to obtain the highest possible use of the locomotive its design will suit it to secondary passenger and freight services and shunting, and since shunting requires vision fore and aft for the driver, it will be of the single-cab type with the engine encased under a bonnet. Such a locomotive should be capable of speeds of 60 m.p.h. with light passenger trains, and on completion it will be used on a variety of mixed services all over the country.

The introduction of main line diesel-electric locomotives will result in a substantial saving of coal; for example, a main line diesel-electric unit of 3200 h.p. would on its annual mileage save some 2500 tons of coal per year.

These experiments are the next step in the development of the diesel locomotive in this country, pioneered by the L.M.S. fifteen years ago. After four years' trial with various types of diesel shunting locomotives a design was evolved in 1936 which became the standard and which was to prove invaluable during the war, not only for use in this country, but also abroad. This standard shunting type is a 350 h.p. diesel-electric unit, the engine and electric transmission being manufactured by the English Electric Company. The L.M.S. now has forty of these locomotives in service and ten are under construction, whilst the building of a further hundred was deferred during the war. Each of these engines consumes 50 tons of oil per annum, against a coal consumption of 600 tons per annum with steam locomotives. When the diesel-electric locomotives under construction are completed it is stated that the aggregate reduction in coal consumption will be 30,000 tons per annum.

The data which have been obtained of the performance of diesel-electric shunting locomotives show clearly that they have proved very successful where continuous twenty-four hour operation is required in important traffic yards, such as Toton, Willesden, Crewe, Carlisle, and Liverpool (Speke). We are informed that the L.M.S. plans to build 100 more diesel-electric shunting units in the next six years.

L.C.C. Scheme for London Reconstruction

THE Town Planning Committee of the London County Council submitted to the council, at its meeting on Tuesday, March 25th, important proposals involving post-war replanning and reconstruction projects. Brief particulars are as follows:—

REDEVELOPMENT OF THAMES SOUTH BANK

The London County Council, as town planning authority, has long been interested in securing a worthy redevelopment of the south bank of the River Thames. This development, which will ultimately extend, it is hoped, from Westminster Bridge to London Bridge, must be undertaken in sections and the council, under powers obtained by special legislation before the war, has already acquired most of the required property. The chief projects which will occupy this area include Government offices, a cultural centre, and a national theatre.

While the design of each of these projects must be appropriate to its particular function, the London County Council is anxious to secure that the development as a whole between Westminster and Waterloo Bridges shall form a united architectural composition, and the Minister of Works, whose department will be responsible for the erection of the Government offices, has undertaken to co-operate to this end. The council accordingly proposes to appoint, in collaboration with the Minister, an architectural consultant for the development of the whole of this area. It has been decided to appoint to this office Dr. Charles Holden, F.R.I.B.A.

CROMWELL ROAD EXTENSION

The Hammersmith Broadway intersection is one which the Ministry of Transport advises should be considered for improvement at an early stage, and a revised scheme of improvement is proposed for a Cromwell Road extension and for Hammersmith Broadway. The Cromwell Road extension will comprise a road viaduct about half a mile long, and Hammersmith Broadway will be dealt with by a system of roundabout operation at ground level. It is proposed that the viaduct should be constructed first; it would rise to span Hammersmith Bridge Road, Queen Caroline Street and Fulham Palace Road before falling to ground level on the east side of the District Railway.

Much of the traffic now passing through Hammersmith Broadway would be likely to use this viaduct. The completion of London Airport and the construction of the motor road to the west, leading to the Severn Bridge, are likely to result in a considerable increase of traffic entering or leaving London by the Cromwell Road extension route, and a viaduct is desirable in the interests of road safety. On the length of this road for which the Minister of Transport is directly responsible, outside the County of London boundary, it is proposed similarly to provide means for the through traffic to pass over the junction of the Great West Road, Gunnersbury Lane and Chiswick High Road, by means of a fly-over.

The estimated cost of the scheme, for which powers are to be sought, is £3,175,000 gross.

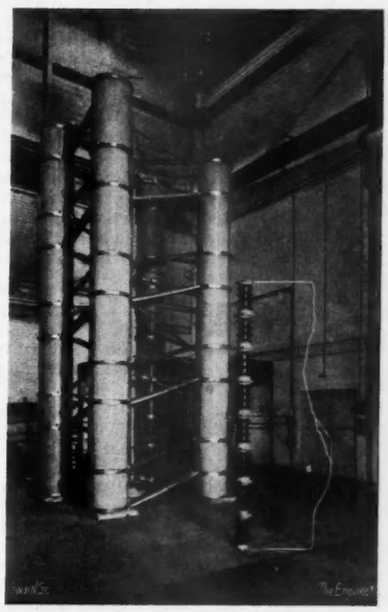
ELEPHANT AND CASTLE RECONSTRUCTION AREA

Six important traffic routes converge on the Elephant and Castle area and form the most important road intersection in London south of the River Thames. The present lay-out is such that traffic is seriously delayed and the capacity of the roads is reduced. A road improvement at this point in the form of a traffic roundabout forms the basis on which the redevelopment of the area is planned. It is proposed that the roundabout shall be elevated to a height of about 6ft above the surface level, with inclined approach roads and shallow pedestrian subways. The roundabout would be hexagonal in shape, about 500ft long by 300ft wide, and would be able to accommodate double the maximum pre-war volume of road traffic. The main roads would be widened, and, in the case of Newington Causeway and Walworth Road, re-aligned. Pedestrian subways will be provided under the roundabout.

The road scheme has been designed on the assumption that the London Passenger Transport Board will take the opportunity of carrying out improvements which will involve, ultimately, closing the existing ground level station buildings and the construction of a new tube station in the central island, serving both the Southern Railway and the Underground Railway. The construction of the roundabout is included in the council's programme of priority road proposals, and work will be started as soon as labour and material are available.

A 2½-Million Volt Surge Generator

WHEN it becomes necessary to employ higher voltages in modern electricity transmission systems the problems associated with insulation and surge conditions are accentuated. Future developments depend particularly upon research into high voltage phenomena and upon progress in the commercial testing of insulators and insulating materials which may be called upon to withstand increased stresses. Surge generators, which play an important *rôle* in this class of work, must therefore be capable of producing "laboratory lightning"



2½-MILLION VOLT SURGE GENERATOR

at potentials corresponding to the higher working voltages now envisaged.

For these reasons the surge generator installed in the high voltage laboratory of the Witton Works of the G.E.C., Ltd., has recently been doubled in output and now generates a maximum of 2·5 million volts, with a stored energy of 40,000 watt-seconds.

In the accompanying engraving the surge generator is shown producing a 2½-million volt discharge across an 8ft gap. The generator consists of four columns, each comprising four interspaced condenser units. The wave control and charging resistances and the interstage sphere gaps are connected between the columns. Each unit has a maximum charging voltage of 160 kV, and a capacitance of 0·2 microfarads. All resistances are of clip-in type, and can be readily changed for any particular investigation.

An important improvement in operating technique is the employment of a modified Marx circuit, which incorporates a damping resistance in each stage, thus more effectively preventing spurious high frequency oscillations from appearing on the peak of the output voltage wave. The standard voltage wave shape is 1—50 microseconds, *i.e.*, the voltage rises to its peak value in one microsecond and falls to one half the peak voltage in fifty microseconds. Waves of 1–5, 1–10, and 10–20 microseconds can be produced by clipping in the appropriate tail resistances. The output voltage is controlled by the interstage spark-gap settings, which are adjusted from a distance by a low-geared motor drive. The maximum stage gap setting is about 7 cm.

The generator can be used also for heavy surge current tests, in which the sixteen condenser units can be readily connected with 2, 4, 8 or 16 stages paralleled. In this manner surge currents up to 90,000 amperes have been recorded.

Industrial and Labour Notes

Successful Private Enterprise

In a speech at Bromsgrove, on Saturday, last, Captain Raymond Blackburn, a Labour Member of Parliament, said that it was an odd paradox that the success of socialism in Britain depended in large degree upon the efficiency of private enterprise. He suggested that an entirely new approach to economic problems was needed, commenting that "we in the Labour movement must realise that export trade is in the hands of private enterprise. Where private enterprise is doing a good job we must help it all we can, and must proudly acclaim its achievements instead of sneering at those who are successful."

"We who engage in politics," Captain Blackburn continued, "have a duty to the country to discourage the notion that the workers can get more money for doing less work. On the contrary, it seems impossible that we can survive as a great exporting nation in the years of competition that lie ahead if there is any substantial reduction in the hours of work in our main industries."

Employment Statistics

Figures issued by the Ministry of Labour at the end of last week, relating to employment in Great Britain, show that in the month of January the total working population of the country was 20,263,000, a decrease of 6000 compared with December. At the end of January, however, the total working population was greater than at mid-1939 by 513,000 (173,000 less men and 686,000 more women).

Between the middle of 1945 and the end of January this year, there was a net increase of 1,837,000 in the number of people employed in industry, the January total in this classification being 18,126,000 (12,534,000 men and 5,592,000 women). There was a further decline in January in the number of those engaged in the manufacture of equipment and supplies for the forces, and at the end of the month it was 447,000, or 823,000 less than the number so employed at mid 1939.

In home civilian industries and services and manufacture for export, there were 17,679,000 people employed in January, a figure approximately 700,000 above the normal pre-war level. Taking the manufacturing industries only, there were, at the end of January, 5,106,000 people employed in the production of goods for the home market, and 1,477,000 engaged in producing goods for export.

Coal Output

Detailed figures concerning coal production in Great Britain in the month of February have now been published by the Ministry of Fuel and Power, and from them it may be seen that the saleable output of mined coal averaged 3,628,800 tons a week. The saleable output of opencast coal in the same period averaged 148,500 tons a week. Both figures are in excess of those recorded for January and for February of last year.

The amount of mined coal lost in February is estimated as being 121,500 tons a week, compared with 168,000 tons a week in January and 60,600 tons a week in February, 1946. There was an appreciable drop in the amount lost in February through disputes, the weekly average being 6800 tons. Accidents, breakdowns and repairs to machinery caused a loss of 28,900 tons a week, and rail transport difficulties and lack of wagons accounted for a weekly loss of 41,600 tons, a figure greatly in excess of that recorded for January, and one which reflects the difficulties caused by the recent severe weather.

The number of wage-earners on colliery books in February was higher than in January, the weekly average being 697,100, of whom 631,800 were "effectively" employed. Voluntary absenteeism amongst coal-face workers was 11·12 per cent—compared with 11·44 per cent in January—and the output per manshift worked at the face was 2·78 tons. Preliminary figures for March indicate that the improvement continues in the manpower situation of the mines, the total number of wage earners on colliery books at March 8th being 701,600. Recruitment figures have increased, and the total wastage has declined.

Coal consumption in February was lower than in January, a fact attributable, of course, to the electricity restrictions which were imposed. Total inland consumption averaged 3,857,000 tons a week, and overseas shipments and bunkers averaged 107,000 tons a week. Provisional figures for the week ending March 8th show that the total inland consumption was 3,819,500 tons, and that total distributed stocks at that date were 5,342,100 tons.

The Aims of Trade Unionism

At a luncheon which took place in London recently, the Council of the British Engineers Association was addressed by Mr. G. W. Thomson, the President of the Trades Union Congress, on the work and aims of trade unionism. Lieut.-Colonel H. B. Riggall, President of the B.E.A., was in the chair, and, in introducing Mr. Thomson, spoke of the growth of collaboration between the two sides of industry. He stressed that the ultimate responsibility for industrial efficiency rested upon both management and workers, saying that it devolved upon the trade unions to impress that fact upon the rank and file of industry.

In his address, Mr. Thomson said that, as an engineer, he had the interests and prestige of the industry very much at heart. Engineering was a facilitating industry, the basis of all other industries, and he believed that the people of the country should understand how greatly it contributed to their welfare, security and comfort. The key position which the engineering industry held in the social structure, Mr. Thomson urged, made it necessary that it should develop a real social conscience to which individual interests would take a second place. The trade unions, he contended, would fail if they thought only in terms of hours and wages, just as would the employers if they concerned themselves solely with profits. The trade unions were a factor in maintaining peace in industry, and Mr. Thomson thought that it was not always recognised that, for every dispute which affected the public, there were a hundred settled by reason and negotiation, of which the public knew nothing.

Mr. Thomson went on to deal with the interest taken by the T.U.C. in fostering education and research as well as in other social improvements. In conclusion, he affirmed his belief that the country was now moving into an era of controlled and co-ordinated economy in which each industry was a unit. He said that he himself, together with the leaders of industry, to whom he was privileged to speak, had a common task in so building up industry that, whatever was ahead, they could collectively be of the highest service to the country.

British Overseas Trade

The Board of Trade Accounts for February, which were published at the end of last week, show that the value of exports of United Kingdom goods during the month was £76,032,619, which was the lowest figure since September, 1946, and £15,167,884 less than that for January. The Board of Trade points out, however, that February is a short month, a fact which accounts for two-thirds of the decline, compared with January. It is also explained that although both land and sea transport were affected by bad weather in February, the fall in production on account of the fuel crisis is not yet reflected in the export figures owing to the time lag which inevitably occurs between manufacture and final shipment. The value of imports in February was £112,535,523, which was just under £9,000,000 below the January figure, and re-exports were valued at £6,605,141, an increase of £1,522,869, compared with January.

Allowing for the rise in prices, the volume of exports in February is provisionally estimated as being 93 per cent of 1938. The total tonnage of machinery exported in February did not differ greatly from the figures recorded for the last four months, and at 52,926 tons was nearly 50 per cent above the 1938 monthly average. Exports of iron and steel and manufactures thereof amounted to 131,917 tons, compared with 181,026 tons in January, the monthly average for 1938 being 159,656 tons. The number of new motor cars exported in February was 7581, a figure still more than double the 1938 monthly average, and exports of commercial vehicles and chassis were three times the pre-war average.

The Census of Production

At the first meeting of the House of Commons Standing Committee on the Statistics of Trade Bill, on March 19th, the Parliamentary Secretary of the Board of Trade, Mr. J. Belcher, announced that the Government had decided to take a full Census of Production in 1949 in respect of the year 1948. Originally, it had been planned to take a Census of Production in respect of 1947, but the Government fully realised, Mr. Belcher said, that this year was proving a particularly difficult one for manufacturers, and did not wish to add to their troubles. The decision had been taken in the confident expectation that industry would co-operate with the Government in giving the full information necessary to make the census a success.

It should be noted that th's decision in no way affects the partial Census of Production for 1946. Manufacturers who have not yet completed their returns for it are asked by the Government to do so as soon as possible, so that the results may be made available in good time. The Board of Trade says that these returns are needed not only because of the light they will throw on the industries affected, but also because of the guidance they can give in the preparation of the schedules for the 1948 census. It is hoped to issue these schedules at the end of the present year to enable manufacturers to become aware of the kind of records they should keep for 1948.

Tin Allocation

A Ministry of Supply announcement says that the Combined Tin Committee has made a further allocation of tin metal in respect of the first half of 1947, bringing the total amounts allocated for that period to 17,700 tons. At the same time, the committee has found that the supply position generally has deteriorated.

In Malaya, for instance, the rehabilitation of the mining industry has been slower than anticipated, and current recovery of production has been handicapped by a shortage of coal among other factors. Shortage of coal has also retarded tin production in the Netherlands Indies, while in Siam exchange problems have made difficult the procurement of tin allocated in 1946. Of the 10,000 tons of tin found in Japan, 6000 tons have already been allocated by the Committee. In China, it is expected that more tin will be available than hitherto, although production at present is far below pre-war levels, owing to economic and transportation problems. Production in Belgium is said to be increasing.

The Combined Tin Committee is not in a position to predict how soon the supply position will improve.

French Engineering News

(From our French Correspondent)

PARIS, March 21st

There are now three plants which are treating bituminous shale. At Autun 1200 tons a month of crude oil is being produced, at Saint-Hilaire production is shortly expected to be 900 to 1000 tons a month, and at Aveyron 200 to 225 tons a month. At Autun the crude oil gives about 50 per cent of its weight in spirit and 25 per cent in coke. The coke is used for the manufacture of electrodes, the gas and residue for heating. At Saint-Hilaire the crude oil gives about 17 per cent petrol, 33 per cent gas-oil and 50 per cent residue. The residue cannot be used as fuel, owing to its high freezing point, but tests are to be made mixing it with gas-oil to see if a suitable fuel can be obtained.

The Vagnas mines have shut down—only temporarily probably—for it is certain that over 5,000,000 tons of exploitable shale are available, and the Vagnas bituminous shale is the richest in France.

* * *

There are two opinions in France on the design of electric cables capable of carrying increased electric power. One is in favour of increasing the capacity of a.c. cables, the other for transmission by direct high-tension current. Several factors regarding the two methods have been specially studied since the last International Electricity Networks Conference. It is known that the use of d.c. over long distances effects economies which compensate for the expense of installations. In addition, high-tension d.c. permits wider use of underground cables; improves stability and control over power surges in cables connecting two networks; limits short-circuit power, as compared with alternating networks; and permits speed of turbines in power stations to be varied as desired. It is also possible to construct rectifiers and switchgear in the required numbers and at reasonable prices.

The use of wind power to generate electricity is still being considered. This assurance was given by the Minister of Industrial Production in reply to a written question. It is still undecided whether to use small apparatus ($\frac{1}{2}$ to 5 h.p.), which would give an irregular supply which could be stored by a battery of accumulators, and would satisfy small local needs and agriculture, or to use large installations (1000 kW), which would be set up in selected sites and would supply the general interconnection network. One hundred metering installations are to be set up in favourable sites to see exactly how much power can be obtained from the wind, so as to decide whether wind can be effectively utilised under modern economic conditions.

* * *

British exhibitors put up a very good show at the first French Agricultural Machinery Salon held since the outbreak of war in 1939. The Export Group of British Agricultural Machinery and Implement Manufacturers was led by its independent chairman, Mr. H. J. Lloyd.

British exhibitors showed no novelties, that is, for British farmers, but French visitors were extremely interested, particularly in grain driers, potato diggers and planters, and all labour saving machinery. One importer of British implements told your correspondent that he could sell a British machine every five minutes. Unfortunately, the French Government will issue no import licences until a new sterling credit agreement is reached. Mr. Lloyd was, nevertheless, quite optimistic about future trade between the two countries.

The French showed some interesting new harvesters and the Usines et Acieries de Sambre-et-Meuse exhibited a new type tractor wheel, to avoid slipping. It comprises a kind of caterpillar wheel but the sections are shaped like horses' hooves. Further, it does not replace the tyred wheel, but is attached to it. When the tractor moves over soft ground the hooves are claimed to dig themselves in and stop slipping. The manufacturers claim that they also afford a considerable saving in the wear and tear of tyres.

Notes and Memoranda

Rail and Road

LOCOMOTIVE FAILURES.—The Minister of Transport has recently stated, in a written reply, that there were 10,152 locomotive failures on British railways in 1946, as compared with 5724 in 1938. The principal causes were fractures, hot bearings, and failures of injectors, joints, boiler tubes and vacuum brakes.

HERBERT JACKSON PRIZE.—The London, Midland and Scottish Railway announces that the Herbert Jackson Prize for 1946 has been awarded to Mr. J. O. Cowburn, formerly engineering research assistant, Derby, for his paper entitled "The Development of a Successful Leakage-Testing Instrument for Use on Vehicles Fitted with the Automatic Vacuum Brake."

LIGHT TANK ENGINES FOR SOUTH AMERICA.—Two standard-gauge 4–6–4 tank locomotives, just completed for the British Guiana Railway by the Hunslet Engine Company, Ltd., are a repeat order to a design evolved twenty-three years ago. The superheater as fitted to the original batch of engines has not been applied, as running experience has shown that saturated steam meets all requirements. Built to the specification and inspection of the Crown Agents for the Colonies, the design of the locomotives is clean and compact. They have a total wheel base of 28ft 4in and a length over buffers of 37ft 8in. Within a total weight of 54½ tons the maximum axle load is only 10 tons, an unusually low value for a standard-gauge engine, but one necessitated by the light rails and bridges on the line out of Demerara, where curves are as sharp as 400ft radius. The capacity of the side tanks is 1600 gallons, and the bunker carries 3 tons of coal. The empty weight is about 41½ tons. As in the original design, the outside cylinders are 16in diameter by 22in stroke, and the boiler pressure is 160 lb per square inch. At 75 per cent boiler pressure the engines have a tractive effort of 14,000 lb, giving a factor of adhesion of 4·7.

Air and Water

EXHIBITION SHIP FOR SOUTH AMERICA.—It is announced that the first post-war "Floating Exhibition" will sail for South American ports at the beginning of next month. The exhibition has been organised by Mr. R. M. S. Morrison, the Latin-American Trade Adviser to a large number of British engineering and industrial concerns, in conjunction with the Saint Line, Ltd. The exhibition is being arranged in the two 'tween deck spaces of the No. 3 hold, in the motor ship "St. Merrial." Ports of call will include Rio de Janeiro, Santos, Montevideo, and Rosario, with Buenos Aires as the destination at the end of the outward voyage. All the exhibits, with the exception of showcases and photographic displays, have already been sold to agents in South Africa and will be forwarded to them from Buenos Aires. The exhibits are over fifty in number, and include a model pile-driver, centrifugal pumps, a mobile crane, agricultural implements, electrical machinery, cables, concrete mixers, small oil engines, motor vehicles, electric battery driven vehicles, and oil drilling equipment. Heavy engineering products are illustrated by means of photographs. Much of the machinery is arranged for demonstration, and a dough-mixer will be used to prepare the ship's bread and cakes while in port.

Miscellanea

NEW TOWN AT HARLOW.—The Minister of Town and Country Planning has announced his decision to make an order under the New Towns Act, 1946, designating Harlow, Essex, as the site for a new town. Certain modifications to the draft designation order have been made, following the report of the public inquiry, thereby reducing the area by 396 acres. The total area now to be designated for the new town is 6320 acres.

CHINA'S COAL AND ALUMINIUM RESOURCES.—Since the end of the war the Chinese Government has assumed control over eight coal mines in the north-east, of which the Fushun mine is the largest. All these mines are now in production, their total monthly output being estimated at more than 400,000 tons. Meanwhile the Government is also taking steps to exploit the rich aluminium deposits in the north-east, which are among the largest in the world. These are mainly located in areas around the port of Yingkow and two railway towns to the east, Kaicheng and Taishikiao.

AMERICAN STEEL PRODUCTION.—According to the American Iron and Steel Institute, the steel industry of the U.S.A. was operating at 92·9 per cent. of capacity in the week ended February 1st, and produced 1,637,300 tons during that week. Steel ingot production in the U.S.A. is now said to be at an annual rate of approximately 85,000,000 net tons.

PRICE OF ALUMINIUM.—The Minister of Supply announces that as from March 24th, the price of virgin aluminium in ingot or notch bar form has been increased from £72 15s. to £80 per long ton, delivered into consumers' works. The new price will apply to metal of a purity of 99 per cent to 99·5 per cent, inclusive, with premiums for higher purities. The increase in price, it is stated, enables the Ministry to average out the cost of metal purchased at home and abroad.

MACHINE TOOL AUCTIONS.—Machine tool merchants, through their advisory panel, have told the Ministry of Supply that they cannot continue to co-operate in working the government's scheme for the disposal of surplus machinery from wartime arms factories unless there is a guarantee that no more of the £50,000,000 worth still stored in various parts of the country will be offered by auction or block tender. Further, the merchants are pressing for an increase of their commission from 7½ to 12½ per cent. in view of the high costs of operating the "fixed price" scheme of selling which has been followed for the past two years.

GAUGE AND TOOL MAKERS' ASSOCIATION.—The Gauge and Tool Makers' Association is arranging a Convention for its members and their business friends in the form of a long week-end at Bournemouth. The Convention will open on Friday evening, June 6, 1947, with a dinner and dance, and will close on Sunday evening, June 8th. There will be organised social activities during the Saturday and Sunday for those wishing to take part. In view of the success of the arrangements last year when a party of members of the Association visited Paris for the International Fair at the Porte de Versailles, it is proposed to organise a similar visit this May. The Association party will leave London on Friday, May 16, 1947, and will return on Tuesday, May 20th.

THE WORLD'S TELEPHONES.—Figures published in a recent issue of *Telephone Engineer and Management* throw a revealing light on the distribution of telephones throughout the world in 1946. With its telephone system privately owned and operated, the U.S.A. has twenty-one telephones installed for each hundred of the population, compared with an estimated average for the whole world of 2·2 telephones per hundred. Countries with nationally owned telephone systems show a wide disparity in telephone development. Sweden, with 17·7 telephones per hundred, is second only to the U.S.A. Australia has 10·9 telephones per hundred, Great Britain 8·2 per hundred, France 4·7 per hundred, and Russia 0·8 per hundred. In five of the largest nationally owned systems, therefore, the average development is represented by a figure of about three telephones for each hundred of the population.

WORLD POWER CONFERENCE AND FUEL ECONOMY.—The World Power Conference is arranging a sectional meeting for the discussion of fuel economy problems, to be held at The Hague from September 2nd to 9th, next. The intention is to consider at this conference wartime experiences in fuel economy, as well as developments since 1939 and the trend of future developments. Papers to be submitted to the conference by the British National Committee include "The British Coal Survey as a Factor in Fuel Economy," by Dr. A. Parker and Mr. A. C. Maries; "Development in Coal-Mining Mechanisation in Great Britain," by Professor Douglas Hay; "Aviation Fuel Production," by Mr. J. A. Oriel and Major K. Gordon; "Fuel Economy in Coal Carbonisation," by Mr. T. C. Finlayson; "The Co-ordination of Electricity Supply," by Sir Johnstone Wright; "The Possibility of Industrial Applications of Atomic Energy," by Dr. J. D. Cockroft; "The Functions of Convection and Radiation in Heating by Gas," by Dr. A. L. Roberts and Mr. L. W. Andrew; "The Availability of Power Station Boilers," by Dr. H. E. Crossley; "Dependence of Gas Turbine Economy on Internal Aerodynamic Design," by Dr. H. Roxbee Cox, Mr. A. R. Howell and Mr. A. G. Smith; and "The Recovery of Industrial Low-Grade Heat," by Dr. W. A. Macfarlane and Mr. J. B. M. Mason. Full details regarding British participation in the conference can be obtained from the British National Committee of the World Power Conference, 201-2, Grand Buildings, Trafalgar Square, W.C.2.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, April 15th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Light and Colour as Applied to Works Equipment," W. Robinson. 6.15 p.m.

Illuminating Engineering Society

Friday, April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "Portable Photometers," J. S. Preston. 6 p.m.

Institute of Economic Engineering

Thursday, April 10th.—MIDLAND REGION: Chamber of Commerce, Birmingham. "Evaluation of Time Study Data," J. R. Whitby. 7 p.m.

Institute of Marine Engineers

To-day, March 28th.—85, The Minories, E.C.3. Annual general meeting. 5.30 p.m.

Institution of Civil Engineers

To-day, March 28th.—YORKSHIRE ASSOC.: Great Northern Station Hotel, Leeds. "Reinforced Concrete Chimney and Offices at the Valley Power Station of the Bradford Corporation," T. H. Carr. 7 p.m.

Tuesday, April 1st.—Great George Street, S.W.1. "Marine Airport Facilities for Civil Flying-Boats," E. C. Hodgson. 5.30 p.m.

Thursday, April 10th.—BIRMINGHAM ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Water Purification," W. S. Thompson.

Institution of Electrical Engineers

Monday, March 31st.—N. EASTERN CENTRE: Royal Station Hotel, Newcastle-on-Tyne. Informal conversazione. 7 p.m.

Monday, April 14th.—S. MIDLAND CENTRE: Midland Institute, Paradise Street, Birmingham. "The Generation and Wholesale Distribution of Electricity," J. Hacking. 6 p.m.

Tuesday, April 15th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Does Standardisation Conflict with Progress?" 5.30 p.m.

Wednesday, April 23rd.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "New Possibilities in Speech Transmission," D. Gabor. 5.30 p.m.

Institution of Factory Managers

Wednesday, April 16th.—S.E. LONDON BRANCH: Bonnington Hotel, Southampton Row, W.C.1. "Education for Management," Colonel L. Urwick. 6.45 p.m.

Institution of Mechanical Engineers

To-day, March 28th.—Storey's Gate, St. James's Park, S.W.1. "The Norwich Heat Pump," J. A. Sumner, and "The Air Cycle Heat Pump," T. F. T. Thomas. 5 p.m.

Saturday, March 29th.—N. EASTERN BRANCH: Gas Showrooms, Grainger Street, Newcastle-upon-Tyne. "Recent Developments in Welding," J. W. Middlemas. 2.30 p.m.

Friday, April 4th.—SCOTTISH GRADUATES: Royal Technical College, Glasgow. "The Machinery of an Oil Cake Mill," R. M. Smith. 7.30 p.m.

Institution of Mining and Metallurgy

Tuesday, April 15th.—The Royal Institution, 21, Albemarle Street, W.1. "The History and Prevention of Silicosis with Special Reference to the Witwatersrand," Major-General A. J. Orenstein. 5 p.m.

Institution of Municipal Engineers

Monday, March 31st.—W. MIDLAND CENTRE: James Watt Institute, Birmingham. "The Birmingham Water Scheme." C. A. Rishbridger. 6 p.m. (Joint meeting).

Institution of Production Engineers

Saturday, March 29th.—YORKSHIRE GRADUATES: Great Northern Hotel, Leeds. "The Application of Electricity for Production," E. C. Walton. 2.30 p.m.

Wednesday, April 9th.—LUTON SECTION: Central Library, Luton. "Shot Peening," W. Neville. 7 p.m.

Thursday, April 10th.—WOLVERHAMPTON SECTION: Station Hotel, Dudley. "Gear Manufacture and Inspection," F. J. Everest. 7 p.m.

Wednesday, April 16th.—MANCHESTER SECTION: College of Technology, Manchester. "Broaching Machines, Tools and Practice," E. Percy Edwards. 7.15 p.m.—SHEFFIELD SECTION: Royal Victoria Hotel, Sheffield. "Stainless Steels," Mr. Tupholme. 6.30 p.m.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Developments in Gear Cutting and Finishing Processes," F. J. Everest. 7 p.m.

Thursday, April 17th.—GLASGOW SECTION: Inst. of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. Annual general meeting. 7.30 p.m.—LEICESTER SECTION: College of Technology, Leicester. Annual general meeting. 6.30 p.m.

Junior Institution of Engineers

To-day, March 28th.—39, Victoria Street, S.W.1. "An Engineer Visits Sweden," Hubert J. N. Riddle. 6.15 p.m.

Wednesday, April 2nd.—MIDLAND SECTION: James Watt Institute, York House, Great Charles Street, Birmingham. "Some Aspects of the Physics and Testing of Electrical Sheet Steels," N. F. Astbury. 6.30 p.m.

Friday, April 11th.—39, Victoria Street, S.W.1. "Pre-stressed Reinforced Concrete," C. E. Reynolds. 6.30 p.m.—WESTERN MEMBERS: Merchant Venturers' Technical College, Unity Street, Bristol. Films, "Valley of the Tennessee," "The Town To-day and To-morrow." 7 p.m.

Friday, April 18th.—39, Victoria Street, S.W.1. "Some Notes on Ropes," R. P. Mears. 6.30 p.m.

Monday, April 21st.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. "Steam Locomotives for Express Traffic on the Railways of Great Britain, 1906–46," C. B. Harley. 7 p.m.

London Association of Engineers

Saturday, April 5th.—Charing Cross Hotel, W.C.2. "Photography in Engineering," G. B. Macalpine. 6.30 p.m.

Manchester Geological and Mining Society

Tuesday, April 15th.—Engineers' Club, Albert Square, Manchester. "Belt Conveyors," J. H. Plumtre. 3.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, March 28th.—Mining Institute, Newcastle-on-Tyne. "Some Gear-Cutting Inaccuracies and their Effect on Gear Loads and Gear Noises," S. F. Dorey and G. H. Forsyth. 6 p.m.

Monday, March 31st.—TEES-SIDE BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough. "The War Effort and Organisation of British Ship Repairing, 1939–45," Sir Lawrie Edwards. 6 p.m.

Friday, April 18th.—Mining Institute, Newcastle-on-Tyne. "Experiments in the Lithgow Propeller Tunnel," A. Emerson and L. W. Berry. 6 p.m.

North of England Institute of Mining and Mechanical Engineers

Saturday, March 29th.—Neville Hall, Newcastle-on-Tyne. "Loading Point Design," J. M. R. Wann; and "The Proposed Pit Bottom Layout at Solway Colliery," J. Fearon and E. Moore. 2.30 p.m.

Royal Aeronautical Society

Thursday, April 10th.—Inst. of Civil Engineers, Great George Street, S.W.1. "A Review of Production Difficulties in Relation to Aircraft Design," C. E. Fielding. 6 p.m.

Thursday, April 17th.—Inst. of Civil Engineers, Great George Street, S.W.1. "Testing Civil Aircraft," P. A. Hufton. 6.30 p.m.

Thursday, April 24th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Risk of Fire and Fire Prevention Methods," J. W. Drinkwater and W. G. Glendening. 6 p.m.

Royal Institution of Chartered Surveyors

Monday, March 31st.—12, Great George Street, S.W.1. "Valuation Problems Affecting Licensed Property," S. Motion. 5.30 p.m.

Royal Institution of Great Britain

To-day, March 28th.—21, Albemarle Street, W.1. "Eclipsing Variable Stars," Sir Harold Spencer Jones. 9 p.m.

Sheffield Metallurgical Association

Tuesday, April 1st.—198, West Street, Sheffield. Paper on "Isothermal Transformations." 7 p.m.

Tuesday, April 15th.—198, West Street, Sheffield. "Origin and Constitution of Certain Non-Metallic Inclusions in Steel," J. L. Rait and H. W. Pinder. 7 p.m.

Society of Chemical Industry

Thursday, April 17th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Modern Road Construction in Concrete," W. P. Andrews. 6 p.m.

Stephenson Locomotive Society

Saturday, April 5th.—EDINBURGH CENTRE: L.N.E.R. Ambulance Room, Calton Hill, Edinburgh. "Locomotives of the Egyptian State Railway," W. Cheyne. 3 p.m.

Saturday, April 19th.—N. EASTERN BRANCH: Central Methodist Church Hall, Newcastle-on-Tyne. "The Churchward Locomotives of the G.W.R.," W. A. Tuplin. 2.30 p.m.

Women's Engineering Society

Thursday, April 10th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester. "Television," N. H. Searby. 6.30 p.m.

Launches and Trial Trips

CALCHAS, motor cargo liner; built by Harland and Wolff, Ltd., for Alfred Holt and Co.; length 487ft, breadth 62ft., depth 35ft, gross tonnage 8298. Engines, double-acting, eight-cylinder, two-cycle; cylinders, 550 mm bore by 1200 mm stroke. Completed, January 17th.

SIRDHANA, passenger and cargo motorship; built by Swan, Hunter and Wigham Richardson, Ltd., for the British India Steam Navigation Company, Ltd.; length 479ft 3in, breadth 62ft 6in, depth 35ft, 8700 tons deadweight. Engines, twin-screw, opposed-piston diesel, with four cylinders, 560 mm bore by 2160 mm combined stroke. Launch, January 8th.

SANGOLA, passenger and cargo motorship; built by Barclay, Curle and Co., Ltd., for the British India Steam Navigation Company, Ltd.; length 479ft 3in, breadth 62ft 6in, depth 35ft, gross tonnage 9430. Engines, twin-screw, opposed-piston, two-cycle, airless-injection, with four cylinders, 560 mm bore by 2160 mm combined stroke. Launch, December 23rd.

Personal and Business

J. SAMUEL WHITE AND CO., LTD., announces that Mr. R. Allen, London manager, has been appointed a director.

BRUCE PEEBLES AND CO., LTD., announces the retirement, on March 31st, of Mr. C. G. L. Preece, M.I.E.E., sales manager.

BULL MOTORS (Branch of E. R. and F. Turner, Ltd.) announces that Mr. J. E. Wright, secretary of the company, has been appointed a director.

MR. H. R. PETERS has been appointed assistant general manager of Specialloid, Ltd. Mr. E. S. Bailey has been appointed home sales manager.

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS has opened a branch office in India, at Jamnabhoomi Chambers, Fort Street, Ballard Estate, Bombay, 1.

DR. LEONARD BAIRSTOW, F.R.S., and SIR WILLIAM HALCROW, M.Inst.C.E., have accepted invitations from the Minister of Civil Aviation to join the Air Safety Board.

LORD DUDLEY GORDON, D.S.O., has accepted the presidency of the Engineering and Marine Exhibition, to be held at Olympia from August 28th to September 13th next.

Mr. F. G. Allen has recently retired from the electrical accessories department of the General Electric Company, Ltd., after over forty-eight years' service with the company.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY announces that its advertising and publicity department is now at Room 400, Euston House, Eversholt Street, N.W.1.

MR. CYRIL M. COHEN has been appointed chairman of George Cohen, Sons and Co., Ltd., in succession to Mr. Lawrence Levy. Mr. Levy remains a director of the company.

THE BRITISH INTERNAL COMBUSTION ENGINE MANUFACTURERS' ASSOCIATION has changed its address to 3, Grafton Street, W.1 (telephone, Regent 5107; telegrams, "Intcomenas, Piccy, London").

POWELL DUFFRYN TECHNICAL SERVICES, LTD., states that its board of directors consists of Mr. Robert Foot, chairman, Mr. Edmund Hann, Mr. H. H. Merrett, Mr. J. G. Bennett, and Mr. W. L. Boon.

THE P.D.N. CASTLE ENGINEERING COMPANY, LTD., 87, Pembury Road, Tottenham, N.17, has been appointed sole agent in London and S.E. England for Hedleys, Ltd., Forward Works, West Bromwich.

DEWRANCE AND CO., LTD., announces the retirement recently of Mr. F. H. Halestrap, chief engineer. Mr. Halestrap, who remains a director of the company, is succeeded as chief engineer by Mr. J. H. Gibson

THE HACKBRIDGE ELECTRIC CONSTRUCTION COMPANY, LTD., HEWITTIC ELECTRIC COMPANY, LTD., and the NEW SWITCHGEAR CONSTRUCTION COMPANY, LTD., have amalgamated and will operate under the title of Hackbridge and Hewittic Electric Company, Ltd. The directors of the three companies are continuing with the amalgamated company, and all business will continue to be carried out in the same factories as hitherto, and under the same management.

THE BRITISH ALUMINIUM COMPANY, LTD., and ALEXANDER BROWN AND CO. announce that by mutual agreement the Scottish business of the British Aluminium Company, Ltd., will be transacted through its own Scottish branch office, to be opened at 113, West Regent Street, Glasgow, C.2 (telephone, Douglas 6528), on July 1st, next. Mr. Peter J. Ferguson has been appointed manager of the new branch. Alexander Brown and Co. will continue to act as principal stockists in Scotland (at 41, York Street, Glasgow, C.2) for the products of the British Aluminium Company, Ltd., which they have handled in the past.

Contracts

THE TRUSSED CONCRETE STEEL COMPANY, Ltd., has received an order from Boot's Pure Drug Company, Ltd., for the reinforced concrete design and construction of a new printing works in Station Street, Nottingham.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY announces that a contract has been placed with Metropolitan-Cammell Carriage and Wagon Company, Ltd., Birmingham, for 200 corridor third-class carriages for main line service.

THE REDHEUGH IRON AND STEEL COMPANY (1936), LTD., has received a contract from the London and North Eastern Railway for the supply and erection of the steelwork for the boiler and pump houses for oil fuelling depots for the coal to oil-fuel conversion scheme for L.N.E.R. locomotives.

A Seven-Day Journal

Shipyard Delays and Prices

A STATEMENT issued on March 24th by the P. & O. and Orient companies states that not least among the troubles of the liner companies to-day are the protracted difficulties in getting their ships reconditioned and the inordinate time required for the building of new passenger vessels. Shortages of steel, timber and innumerable fittings, as well as skilled labour, make fixed dates for completion impossible. The proposed shorter working week in shipyards will aggravate the already difficult position, unless it is accompanied by increased output per man. Each of the two companies has ordered a 29,000-ton liner, bigger than any previously planned for the Australian route. In March, 1945, the Orient Line ordered the "Orcades," the keel of which was laid in August, 1945. This ship was originally expected to be completed in February this year, but completion is now expected about the middle of 1948. The "Himalaya" was ordered by the P. & O. Line in January, 1946, and her keel was laid in April, 1946, but her completion has been postponed from January, 1948, to June of that year. The liner "Chusan" was ordered in May, 1946, and as no berth was available, her keel was not laid until February, 1947. Her completion is likely to be delayed from May, 1948, the original expected date, to October, 1948. Similarly, the reconversion of ships from trooping duties has been held up. Originally estimated as a six months' job, ten months to one year seems now to be required. It is stated that, owing to the causes mentioned, shipbuilding costs to-day are more than two and a half times those of pre-war days. It will be appreciated that such reserves as some of our leading shipping companies have been able to accumulate from insurance moneys received in respect of ships lost in the war and by allocations from profits in the past will be insufficient for the task of rehabilitating their fleets. Further orders may have to be deferred until the cost of building a new passenger vessel is such as to represent a reasonable economic venture.

Weather Ships

IT is announced by the Meteorological Office of the Air Ministry that four ships for meteorological observations are now being prepared in the Royal Dockyards, and that the first will be ready for service in July. For many years selected ships of the mercantile fleet have sent weather reports to the Meteorological Office by wireless telegraphy every six hours. These reports are, of course, confined to the regular shipping lanes in the North Atlantic and other waters, and the intervening spaces are unrepresented. In order to cover this weakness, the Provisional International Civil Air Organisation (P.I.C.A.O.), succeeded in September, 1946, in inducing the governments of several European and American countries to agree to set up a network of weather ships in the North Atlantic. The United Kingdom has accepted the responsibility for two of these stations with two ships each, and joint responsibility with Norway and Sweden for a further station with two more ships. The British ships are Navy corvettes, having a length of about 205ft, and a displacement of 1400 tons. They have been chosen for seaworthiness and economy, and have oil-burning boilers and single-screw reciprocating steam engines designed for a speed of about 14 knots. They will be twenty-seven days at sea and fifteen in port, and will carry a complement of fifty-four officers and men. Of these, seven will be meteorological officers, and thirteen radio and radar officers, who will be engaged largely on the observation work and the transmission of reports. Balloons will take radio "sondes," or meteorological instruments, up to heights of, say, 30,000ft; 60,000ft or more being obtained on land. At these heights the barometric pressure, temperature and humidity will be measured, and in addition radio-reflecting targets will be carried, so that distance and position can be measured by naval radar equipment Type 277, installed on the ships. The conversion of the ships includes new accommodation for sea-keeping purposes, additional lifeboat equipment, and higher powered electric generating plant. One ship is being converted at Sheerness, another at Devonport, and two others at Rosyth.

The Government's Chief Planning Officer

THE Prime Minister announced in Parliament on Thursday, March 27th, that Sir Edwin Plowden had agreed to accept appointment as the Government's chief planning officer. Sir Edwin, who served during the war as chief executive in the Ministry of Aircraft Production, is a director of C. Tennant and Sons, Ltd., and a member of the British South American Airways Corporation. In making the announcement, the Prime Minister explained the constitution and functions of the Inter-departmental Planning Staff which Sir Edwin will supervise. Its primary task, he said, would be to develop the long-term plan for the use of the country's manpower and resources. It would also follow through the implications of the economic survey set out in the recent White Paper, keeping in touch with all Government departments so as to correlate their action under the plan. The approach, the Prime Minister stressed, must essentially be a practical one, and both sides of industry would be kept in contact with the progress of the planning, through a planning board which the Government intended to establish. The chief planning officer, the Prime Minister continued, would work directly under the Lord President of the Council and would have access to all Ministers concerned with production matters. All decisions on planning policy would be made by the Cabinet and not by the chief planning officer, and responsibility for those decisions must reside wholly with Ministers. The Prime Minister went on to point out that it would be a mistake to assume that the present difficulties of under-production could be solved by planning alone. The function of planning was to enable decisions to be reached as to the best allocation of available manpower, materials, services and manufacturing capacity, and in itself planning was no substitute for the increased effort and efficiency which were essential to the national prosperity. The Prime Minister announced also that Sir Robert Sinclair, who served during the war as chief executive at the Ministry of Production, had agreed to act as industrial consultant to Sir Edwin Plowden in the initial stages.

The 1851 Exhibition Centenary

IN a Journal note of February 14th we referred to the conference held at the Society of Arts, on the Proposed International Exhibition in 1951, and the views in favour of the exhibition then put forward. In a written reply to a question in the House of Commons, Sir Stafford Cripps, the President of the Board of Trade, said, on Friday, March 28th, that the possibility of holding such an exhibition had been the subject of long and careful enquiry. As a result, he had most reluctantly concluded that it would be impossible to stage such an exhibition in that year, involving large-scale demands on labour and material without impeding the progress of urgent tasks of reconstruction. He was convinced, however, that this country would derive many advantages from such an exhibition, and the proposal would be reviewed in a few years' time, when the competing claims on our national resources could be more clearly seen. The centenary of the Great Exhibition of 1851 should, however, he thought, be marked by some national display, such as a cultural festival, and a design display on the lines of the recent "Britain Can Make It" Exhibition. Statements on these matters would be made in due course. Sir Stafford then went on to say that he had not overlooked the Ramsden Committee's recommendation that a permanent centre for the British Industries Fair should be erected as soon as practicable. Difficulties with regard to the diversion of labour from an already crowded programme of works were again involved. He was, however, having examined the possibility of making some advance towards the attainment of that objective as part of the recognition of the centenary of the 1851 Exhibition.

Research and the Ministry of Supply

IT is announced by the Ministry of Supply that Sir Frank Smith has retired from the Chairmanship of the Ministry of Supply Advisory Council on Scientific Research and Technical Development, and that he will be succeeded in that office by Sir John Lennard-Jones. We may recall that Sir Frank, who is now director of research at the Anglo-Iranian Oil Company, served as the Chairman of the Advisory Council of the Ministry of Supply almost from its inception early in the war. Although he has retired from that post, Sir Frank will, we learn, be still connected with several Government committees, and he will remain chairman of the Radio Research Board. Sir. John Lennard-Jones, who has been chosen to succeed him as the chairman of the Advisory Council, joined the staff of the Ministry of Supply in 1942 as Chief Superintendent of Armament Research, and he was appointed Chief Scientific Officer in September, 1945. Later he was appointed Director-General of Scientific Research (Defence) in the Ministry. Last August, Professor Lennard-Jones returned to Cambridge in order to take up his duties as Professor of Theoretical Chemistry at Cambridge. Since that time he has been Chief Scientific Adviser to the Ministry of Supply.

British Society of International Bibliography

THE British Society of International Bibliography has called an extraordinary meeting for Tuesday, April 15th to ratify a resolution of its Council that a new, independent British National Committee of the International Federation of Documentation (F. I. D.) shall be formed, which will be fully representative of the organisations having a direct interest in documentation. Since the formation of the Society in 1927, the B.S.I.B. has been the British National Section of the F.I.D. At the meeting of the council of the F.I.D., which took place in Paris in November last, it was suggested that in each country there should be a national committee rather than a national section. Bearing this in mind, the Council of the B.S.I.B., in reviewing the present position in this country, has noted that a Sectional Committee on Standardisation of Documentation, recently formed by the British Standards Institution, is fully representative of the organisations directly interested in documentation. The B.S.I.B. Council is further of the opinion that the time has now come for its Society to hand over its functions as the British National Section of the F.I.D., to a representative British National Committee. It has therefore put forward the following resolution: "That the B.S.I.B. initiate the formation of an independent British National Committee of the F.I.D., the personnel of which shall be as far as practical identical with that of the B.S.I. Sectional Committee on Documentation." The resolution requires no alteration of the rules of the Society, and the hope is expressed that the members of the Society will ratify it, so that the necessary steps to implement it can be taken. By such an action it is felt that the work of the Society will not be impaired but will be greatly strengthened.

Historic Researches*

No. XXII—MOLECULAR PHYSICS

(*Continued from page 257, March 28th*)

Rudolf Clausius (1822–88) was born at Köslin, Pomerania. His early training was acquired at Stettin Gymnasium. Later he studied at Berlin and Halle universities. He graduated in 1848 and two years later was appointed Professor of Physics in the Royal Artillery and Engineering School at Berlin. In 1855 he went to Zürich to take up a professorship at the Polytechnic, and simultaneously at the university of that city. There he remained until 1867, when he was appointed Professor of Physics at Würzburg. Two years later he assumed the same Chair at the University of Bonn and continued to hold that position until his death. Clausius was much more of a mathematical than an experimental physicist. His contributions to the development of the dynamical theory of gases were numerous and of the first importance, so much so that Clerk Maxwell himself acknowledged him as being one of the principal founders of the theory. In addition to his work on molecular physics, he will always be remembered for the leading part which he played in the foundation of the science of thermodynamics. He shares with Lord Kelvin credit for the early recognition of the fundamental importance of Carnot's principle, and was mainly responsible for introducing the conception of entropy into the theory of the heat engine.

AT the Swansea meeting of the British Association, held in August, 1848, J. P. Joule presented a paper, entitled "On the Mechanical Equivalent of Heat, and on the Constitution of Elastic Fluids." In October of the same year he read before the Manchester Literary and Philosophical Society a very similar paper, "Some Remarks on Heat and the Constitution of Elastic Fluids." These two addresses marked the opening of the new attack on the problem of the molecule and its physical behaviour.

Joule approached the subject armed with the conviction—not yet fully shared by all his contemporaries—that heat was a form of motion and not a material substance, and that it was to be identified with the kinetic energy of the ultimate particles of a body.† Further, he knew that mechanical work—and also electrical energy—could be converted into heat and from the experiments which he had been conducting since the spring of 1844 he had arrived at a fairly accurate value—770 or 771 foot-pounds—of the mechanical work equivalent to the heat required to raise a pound of water through 1 deg. Fah. One other vital piece of information was also in his possession. He knew that the pressure of any gas heated or cooled at constant volume rose or fell by one part in 491, or thereabouts, for every degree Fahrenheit by which its temperature was raised above or lowered below 32 deg.

Joule saw that with the information at his disposal he was in a position to calculate the specific heat of a gas at constant volume, and, by comparing the calculated result with that found by direct experiment, to put the impact or dynamical theory of gaseous pressure to a practical test.

We have seen that according to the Bernoulli impact theory, the product pV of the pressure and volume of a gas is equal to two-thirds of the total kinetic energy possessed by its molecules by virtue of their linear velocities; that is to say, $E = {}^3/_2\, pV$. Thus from a knowledge of p and V we can readily calculate the total kinetic energy contained in a given mass of gas by virtue of the motion of its molecules. The value arrived at will be expressed in mechanical units—for example, in foot-pounds. Joule argued that, as heat was identifiable with the kinetic energy of the molecules, he had only to divide the above-named quantity ${}^3/_2\, pV$ by J, his mechanical equivalent of heat, to obtain the value of the heat contents of the gas in thermal units. Thus the total heat contents of a pound of gas occupying a volume V and under a pressure p would be ${}^3/_2\, pV/J$.

If now the gas were heated at constant volume through 1 deg., say, from 32 deg. to 33 deg., its pressure, Joule proceeded, would increase by an amount $p/491$, and therefore its stock of molecular heat energy would rise by the amount ${}^3/_2 \cdot (p/491)\, V/J$. This, then, he concluded, should be the heat required to raise 1 lb of the gas through 1 deg. or, in other words, its specific heat at constant volume.

To complete the calculation for any gas all that is required, in addition to the value of J, is the volume occupied by 1 lb of it at some stated pressure, say, atmospheric. Using the best available data, Joule calculated by means of the formula what the specific heat of hydrogen at constant volume should be. It came out at 1·5157. The best available experimentally determined figure at the time was that found by Delaroche and Berard. It was 2·352 or over 50 per cent greater than the calculated value.

Joule also calculated in the same way the specific heats of aqueous vapour, nitrogen, oxygen and carbon dioxide. In every instance the theoretical figure was materially less than the experimental value.

Joule suggested that the experimental values of the specific heats were probably inaccurate, and that until the results of Regnault's reinvestigation of them—then in process of being carried out—were published, it would "be better to delay any further modifications of the dynamical theory, by which its deductions may be made to correspond more closely with the results of experiment." His hopes in this direction were not fulfilled. Further research on every item in the count, including his own more accurate determination of the mechanical equivalent, has widened and not narrowed the discrepancy between the experimental values of the specific heats of gases and those calculated by Joule's method. Thus, taking accepted modern data we find that the specific heat of hydrogen at constant volume should be 1·481, whereas by direct experiment it is now known to be 2·402.

It can be inferred that Joule was somewhat chagrined at the failure of the impact theory to yield results for the specific heats of gases in close approximation with experiment. At any rate, he never returned to the subject again.

Others, however, were not disheartened. Among those who continued to study the dynamical theory of gases was the German mathematical physicist Clausius. His earliest contribution to its development was published in 1857 and contained a remarkably illuminating result. Joule's formula gives the theoretical value of the specific heat of a gas at constant *volume*. Clausius set out to arrive at a similar formula for the specific heat at constant *pressure*. He argued that the heating of a gas at constant pressure could be regarded as consisting of two stages. During the first the gas could be supposed to be heated at constant volume, its pressure being allowed to rise with the temperature. Joule's argument would apply to this stage. During the second stage the gas, at the elevated pressure and temperature reached during the first, could be supposed to expand from the elevated pressure back to the original pressure. This expansion would involve the performance of work by the gas against the external pressure and it would cool. But if additional heat exactly equivalent to the external work done by the gas were added to it during the expansion its temperature would remain at the elevated value reached during the first stage. Thus at the end of the combined processes the gas would have the same pressure as originally but its temperature would be higher and its volume greater. In other words, it would have been heated at constant pressure.

It is a simple matter to evaluate the amount of heat taken in by the gas during each of the two stages. It is found that the two amounts are exactly in the ratio of 1 to ${}^2/_3$. From this it follows that the specific heat at constant pressure should for any and every gas be exactly $1{}^2/_3$ times its specific heat at constant volume; that is to say, the ratio γ of the two specific heats should in every case be equal to ${}^5/_3$. An appended mathematical note gives details of the argument.

The value of the ratio γ can be determined experimentally in a direct manner with considerable accuracy. For example, γ is a factor in the formula for the velocity of sound in a gas. Hence a measurement of that velocity yields its value without necessitating the determination of the two specific heats separately. In 1857 the experimental values of γ were known with less accuracy than they are to-day. But the existing knowledge was sufficiently exact to show that in every instance except one the actual value of γ was less than Clausius' calculated value and that it was not the same for all gases. It was in most cases much nearer 1·4 than 1·6. The exception was mercury vapour for which the value of the ratio appeared to be very close to ${}^5/_3$. Some years later, in 1876, Kundt and Warburg measured the value of γ for mercury vapour at 310 deg. Cent. with great accuracy. They found it to be exactly 1·666.

To-day we know five other gases with values of γ equal or very nearly equal to ${}^5/_3$. For the inert gases γ ranges from 1·63 in the case of helium to 1·689 in the case of krypton.

Unaware of the existence of these five rare

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* Nos. I, II and III, on "Friction," appeared July 14, 21 and 28, 1944; Nos. IV, V and VI, on "The Mechanical Equivalent of Heat," appeared September 29, October 6 and 13, 1944; Nos. VII, VIII and IX, on "Electro-Dynamics," appeared March 9, 16 and 23, 1945; Nos. X, XI and XII, on "The Ether Drift Experiments," appeared August 3, 10 and 17, 1945; Nos. XIII and XIV, on "Specific, Latent and Atomic Heats," appeared December 7 and 14, 1945; Nos. XV, XVI, XVII and XVIII, on "Chemical Elements and Atoms," appeared August 2, 9, 16 and 23, 1946; Nos. XIX and XX, on "The Classification of the Elements," appeared September 27 and October 4, 1946.

† In 1848 "energy" and "kinetic energy" had not entered the vocabulary of physicists. Throughout both the addresses mentioned Joule used the old term *vis viva*.

gases, Clausius was concerned to find an explanation of the fact that for air, hydrogen, nitrogen, oxygen and other familiar gases the ratio γ differed from gas to gas, and in every instance was less than $^5/_3$. He arrived at a very elegant conclusion. Was it justifiable, he asked, to assume, as he and Joule had done, that when a gas was heated the heat absorbed went entirely towards increasing the *linear* velocity of the molecules? Each molecule might be supposed to consist of two or more atoms rotating planetwise about some common centre, or even vibrating to and fro as a group. Without departing in the least from the conception of heat as a form of motion, was it not possible to suppose that some portion of the heat absorbed went towards increasing the rotational or vibrational velocity of the atoms composing the molecules? Any energy so absorbed would be ineffective so far as the pressure of the gas was concerned. The pressure would remain dependent upon the impact of the molecules; that was to say, upon their *linear* velocity.

Conversely, Clausius argued that when a gas cooled it lost heat partly at the expense of the linear kinetic energy of its molecules and partly at the expense of the kinetic energy of their atomic rotation or vibration. Going one step further, he assumed that in any gas the total heat contents were always divided in constant ratio between the rotational or vibrational kinetic energy of the atoms composing the molecules—the atomic energy, as it might be called—and the linear kinetic energy of the molecules themselves—the molecular energy. The modern reader should be careful to avoid confusing the term "atomic energy" as here used with its current use in connection with nuclear fission. The one is kinetic or thermal energy and is dependent upon the velocity of the atoms within the molecule. The other should more properly be called nuclear energy, because it is dependent upon the conversion of a portion of the nuclear mass into energy.

Denoting the ratio of the atomic to the molecular kinetic energies by the symbol β, Clausius repeated the calculation of the specific heats of a gas. He found that the specific heat at constant volume should be $(1+\beta)$ times the value given by Joule's formula and that the ratio of the two specific heats should be $1+2/(3+3\beta)$ instead of $1+^2/_3$. Details of Clausius' theorem are given in the second appended note.

Since negative kinetic energy is meaningless, the factor β, being the ratio of two quantities of energy, cannot have a value less than zero. If it is zero all the kinetic energy is molecular or linear, and $\gamma=1^2/_3$, as in the case of mercury vapour, and the five inert gases. For β greater than zero γ will be less than $1^2/_3$. If it becomes exceedingly great, implying that substantially all the kinetic energy is atomic or rotational, γ approaches the limiting value of unity. We can therefore say that, according to Clausius' theorem, the ratio of the specific heats of any gas must lie between unity and $1^2/_3$. This conclusion is fully supported by experimental evidence. No substance in the truly gaseous state, with the possible exception of krypton, has been found to have a value of γ greater than 1·666. None has been found to have a value of γ less than unity. In no case is it even approximately unity. If a gas with $\gamma=1$ existed it would, according to Clausius' theorem, behave in a very peculiar manner. The application of heat to it would have the sole effect of increasing its atomic energy. None would appear as molecular or linear energy, and therefore the gas would fail to show any increase of pressure when heated.

From Clausius' formula, $\gamma=1+2/(3+3\beta)$, it is evident that the value of β for any gas can be calculated from an accurate measurement of the ratio of its specific heats. Thus, for hydrogen at 16 deg. Cent. the value of γ, according to modern observations, is 1·407, which gives us $\beta=0{\cdot}638$. This value of β implies, according to Clausius' theorem, that about 61 per cent of the heat contained in any given quantity of hydrogen is in the form of linear, or molecular, kinetic energy and 39 per cent in the form of rotational, or atomic, kinetic energy. In the case of carbon dioxide, β is as high as 1·22, which implies that only some 44 per cent of the heat contents of this gas is in the form of linear kinetic energy.

If γ is exactly or approximately 1·666, as it is for mercury vapour and the five inert gases, then β must be zero or substantially so. The implication is that in these gases all, or practically all, the heat is in the form of linear kinetic energy and that none is stored as rotational or vibrational energy of the atoms within the molecule. This deduction is in beautiful harmony with facts discovered since Clausius' time. Chemical evidence has definitely shown that the molecules of mercury vapour and the five inert gases are exceptional in that each consists of but one atom. A single atom cannot rotate planetwise or vibrate to and fro about some immaterial point external to itself. It can, however, increase its stock of kinetic energy by increasing its linear speed. This consideration explains why in the case of a monatomic gas β is zero and γ is $1^2/_3$.

The molecules of hydrogen are known to consist of two atoms. Planetwise rotation or vibrational motion of each pair of atoms is physically possible, and therefore in hydrogen and the other diatomic gases part of the heat can exist as kinetic energy of the atoms within the molecule, and part as linear kinetic energy of the molecule as a whole. It would seem reasonable to assume that the greater the number of atoms in the molecules of a gas the greater will be its capacity for absorbing heat in the form of atomic kinetic energy. This inference illuminates the high value found for β in the case of carbon dioxide and other polyatomic gases.

Joule, it will be recalled, deduced his formula for the specific heat of a gas at constant volume on the assumption that any heat added to it went entirely towards increasing the linear kinetic energy of its molecules. He found, as we have seen, that his formula gave results which were invariably less than the experimentally observed figures. If, as Clausius suggested, only part of the heat is so absorbed, the remainder appearing in the form of atomic kinetic energy, then, as we have previously said, Joule's calculated figures ought to be multiplied by the factor $(1+\beta)$. This consideration affords us an additional opportunity of testing the validity of Clausius' theorem, and incidentally that of the impact theory of gaseous pressure.

Using modern data, we have already found that the specific heat of hydrogen at constant volume should, according to Joule's formula, be 1·481. For hydrogen β has the value 0·638. Hence on the basis of Clausius' theorem, the specific heat should be 1·638 times Joule's figure or 2·426. The experimentally observed value is 2·402. In the case of oxygen Joule's formula gives 0·093 as the specific heat at constant volume. Clausius' correcting factor $(1+\beta)$ for this gas is 1·67. The corrected value is therefore 0·1558; the experimental figure is 0·1544. In both these cases theory and experiment agree to within 1 per cent.

As a third test, let us take the case of argon. For this monatomic gas the specific heat ratio γ is found to be almost exactly $1^2/_3$. Hence β is zero, and therefore Joule's formula for the specific heat at constant volume should require no correction. That deduction is correct. The formula yields the value 0·0746, a figure which is in complete agreement with the experimental value.

Mathematical Notes

Specific Heat at Constant Pressure.—Consider a volume V of gas of mass M at pressure p and temperature T. By Bernoulli's theorem $pV=^1/_3Mv^2$ or $E=^3/_2pV$, where E is the total kinetic energy corresponding to the linear velocity of the molecules. Let the gas be heated at constant volume to a temperature $T+\delta T$ by applying to it a quantity of heat H. The pressure will rise to $p\ (1+\alpha\,.\,\delta T)$, where α is the pressure coefficient and therefore the molecular energy will increase by $^3/_2pV\alpha\,.\,\delta T$. Hence if all the heat H is absorbed in increasing the linear velocity of the molecules, we will have $H=^3/_2pV\alpha\,.\,\delta T/J$. But, by the definition of specific heat, $H=C_VM\,.\,\delta T$. Hence $C_V=^3/_2pV\alpha/JM$. This is Joule's result. Next let the gas be expanded back to the original pressure p, the temperature remaining at the value $T+\delta T$ reached during the previous heating at constant volume. Since the expansion takes place at constant temperature, Boyle's Law will apply, and therefore we will have $p\ (1+\alpha\,.\,\delta T)\ V=p\ (V+\delta V)$, or $\delta V=V\alpha\,.\,\delta T$. The work done by the gas during expansion will be $p\,.\,\delta V=pV\alpha\,.\,\delta T$, and if the temperature is to remain constant heat, h, equivalent to this work must be added to the gas. Thus $h=pV\alpha\,.\,\delta T/J$. Taking the two stages together, the total heat required to raise the gas through the range δT, the pressure being the same after heating as before, will be $H+h=^5/_2pV\alpha\,.\,\delta T/J$. But by the definition of specific heat, $H+h=C_pM\,.\,\delta T$. Hence $C_p=^5/_2pV\alpha/JM=^5/_2\,C_V$ and therefore $\gamma=C_p/C_V=^5/_3$.

Clausius' Theorem.—Let it be assumed that when a gas is heated by applying to it a quantity of heat H part only of this heat, say, H_M, is absorbed in increasing the linear kinetic energy of the molecules, while the rest, say, H_A, goes to increase the rotational or vibrational kinetic energy of the atoms within the molecules. Let the ratio $H_A/H_M=\beta$ and let β be assumed constant for any one gas at all temperatures. Repeating the argument of the preceding note, we see that for the initial heating of the gas at constant volume we must now write $H_M=^3/_2pV\alpha\,.\,\delta T/J$. The total heat to be supplied will, however, be $H=H_M+H_A=(1+\beta)\ H_M$, and therefore the specific heat at constant volume given as before by $H=C_VM\,.\,\delta T$ will now become

$$C_V=(1+\beta)\,^3/_2\,pV\alpha/JM,$$

or $(1+\beta)$ times Joule's value. During the subsequent expansion at constant temperature the work done by the gas will, as before, be $pV\alpha\,.\,\delta T$, and if no additional heat were supplied would be done partly at the expense of the linear kinetic energy of the molecules and partly at the expense of the rotational or vibrational kinetic energy of the atoms. The ratio of these two parts would be β. Hence $pV\alpha\,.\,\delta T=\delta E+\beta\,.\,\delta E$. If the temperature is to remain constant during the expansion, heat, h, sufficient to make good both these portions of energy must be supplied to the gas; that is to say, the heat h must be divided in the ratio β such that $h_M=\delta E$ and $h_A=\beta\,.\,\delta E$. From this it follows, as before, that $h=pV\alpha\delta T/J$. The specific heat at constant pressure, given by $C_p=(H+h)/M\delta T$, will thus become

$$C_p=\left\{(1+\beta)\,^3/_2+1\right\}pV\alpha/JM,$$

and therefore the ratio of the specific heats will be

$$\gamma=1+\frac{2}{3\,(1+\beta)}.$$

(*To be continued*)

The Institute of Metals

No. IV—(*Continued from page 259, March 28th*)

THE final session was held on Friday morning, March 7th, and opened with a paper entitled :—

OBSERVATIONS ON THE RATE AND MECHANISM OF RECRYSTALLISATION IN COPPER

By Maurice Cook, D.Sc., Ph.D. (Member), and T. Ll. Richards, B.Sc., Ph.D. (Member)

Synopsis

The rates of recrystallisation in copper strip on annealing at 27 deg., 50 deg., 72 deg., 100 deg. and 125 deg. Cent. have been studied, using the same material as that employed in a previous investigation on the self-annealing of copper, namely, strip with initial grain sizes of 0·015–0·02 mm, 0·025 mm and 0·06 mm, cold rolled with reductions of 80, 90, 95 and 97·5 per cent. The results indicate that the softening of heavily cold-rolled strip takes place by a two-stage activated process ; recovery followed by recrystallisation. The process occurs both in copper strip with twin textures which anneals to a single-texture structure, and in copper in which the twin textures recrystallise independently, the activation energy of the former being approximately two-thirds that of the latter. It appears that when recrystallisation takes place by a merging of the twin textures the energy of lattice distortion due to the twin relationship contributes one-third of the activation energy required. At the temperatures considered, *i.e.*, 27 deg. to 125 deg. Cent., the size of the recrystallisation nucleus varies from about 3·5 to $5{\cdot}5\times10^{-5}$ cm. When strip is cold rolled with reductions which decrease the initial mean diameter of the crystals to thicknesses less than these values the material recrystallises by a merging of the cold-rolled twin textures, the critical thickness to which it is necessary to reduce the crystals for this to happen being directly proportional to the absolute annealing temperature.

Dr. M. Balicki said that the authors had referred to the quantitative theory of recrystallisation published ten years ago by A. Krupkowski and himself. Despite the evidence he had amassed since then, to which they had access, they now denounced the theory as incapable of accounting for the early stages of softening of work-hardened metals, and proceeded to develop a better theory based on the two-stage mechanism of softening.

Some twelve years ago he and Krupkowski had seriously entertained the idea, then very fashionable, that "recovery" or "relaxation" preceded the actual softening, and had tried to find experimental confirmation. The results were negative, and they were forced to accept the simpler model of the process, *i.e.*, the single-stage one. Having examined the facts and data now gathered by Dr. Cook and Dr. Richards, he had again failed to find any convincing support for the existence of a stage preceding softening which would be other than strain-age-hardening. For that reason he could not admit the necessity for speculation about "recovery" or "relaxation" as being anything different from recrystallisation. Among the facts presented he did not see any features of importance which could not be adequately explained or accounted for quantitatively by the older theory. It appeared that only so far as the isothermal annealing of metals was concerned were the authors right in stating that the rate of annealing according to the theory of Krupkowski and Balicki did not agree well with experimental results, but they must agree that the same was even more true of their own theory. Thus, they seemed to have left the principal problem exactly where they had taken it up.

Mr. P. C. Varley referred to some preliminary results which he and his colleagues had obtained in experiments with aluminium. They had tackled the problem by measuring the variation of ultimate tensile strength with time at various temperatures, and had obtained curves which, whilst similar in some respects to those obtained by the authors for copper, differed in one or two particulars. There was no sign of any initial flat portion, the curves sloping right from the beginning. In addition, according to the authors, with copper there were signs of recrystallisation right at the start. He and his colleagues, on the other hand, had obtained the first signs of recrystallisation at an ultimate tensile strength of about 8 tons, though it varied a little. The first signs of recrystallisation did not appear until the softening was at least half way to completion. Their method of detecting recrystallisation, however, was not the same as that used by the authors. They had relied so far on the appearance of the first new spots on the X-ray photograph, and perhaps that was not so delicate as the microscope in the case of copper.

Mr. McLean said it was shown that with rapid heating a smaller grain size was obtained than with slow heating. One of the possibilities arising out of that was to produce by high temperature flash heating a fine grain size resistant to grain growth at lower temperatures.

Dr. J. C. Chaston said the subject was capable of raising a tremendous amount of argument, and much of the argument was due to the lack of sufficient experimental evidence. We needed more and more careful experimental evidence before starting to demonstrate our theories. A matter which worried him very much was the effect of impurities. We were considering an atomic rearrangement, and were thinking of all the factors which affected that rearrangement. The authors had used copper of 99·95 per cent purity, with 0·044 per cent of oxygen, and a little silver and iron. Purer copper than that could be obtained. One of the things needed was more experimental work with materials of known purity. Probably we should not be able to achieve absolute purity, so that we should have to experiment with two or three grades of copper and draw conclusions as to the effect of impurities.

Mr. Noakes said the authors had tested some of the copper in a state in which it was composed of two phases, one hard and one soft. Surely, then, one would expect a wide variation in the hardness measurements made on that copper. He asked whether the figures plotted in their graphs and shown in their tables were the averages of large numbers of readings, and, if so, how wide was the range of the practical determinations. He suggested that a better picture would be presented if, instead of a line drawn between a number of probable average points, a band was used covering all the experimental results. Possibly on that band the average curve could be plotted.

Dr. Richards said he could not hope to reply adequately to Dr. Balicki at the meeting, but hoped to do so in writing. But clearly the issue was whether recrystallisation in general was a single-stage or a two-stage process, and Dr. Balicki had analysed the data given in the paper and had tried to use them in support of his argument. He had also suggested that they had chosen rather a doubtful method of determining which of the two theories was correct. That must be left to the judgment of others. Dr. Balicki had shown that with his cold-rolled material at fairly heavy reduction there was a very good agreement between recrystallisation as a single-stage process and the experimental results. But the evidence presented in the paper was equally good evidence that recrystallisation in heavily cold-rolled copper strip was a two-stage process. He (Dr. Richards) had also made extensive observations of recrystallisation in cold-drawn wire. The evidence so far was that recrystallisation in the early stages of drawing was a two-stage process, and in the later stages it was a single-stage process. He did not know why.

The second and final paper of the session was entitled :—

A THEORY OF THE AGE HARDENING OF ALUMINIUM-COPPER ALLOYS, BASED ON VACANT LATTICE SITES

By F. Röhner, Ph.D. (Member)

Synopsis

In Part I of the paper a description is given of the results of an investigation of the age hardening at room temperature of four different high-purity alloys of the duralumin type by measurements of tensile properties and electrical resistivity. A deductive analysis of the rejection of solute atoms from a supersaturated solid solution shows that this process must be preceded by an incipient stage, consisting in an egress of solute atoms to the interstitial lattice space. The kinetics of this egress are deduced. The interpretation of these results leads to a new theory of age hardening. The egress of solute atoms creates vacant sites in the lattice. It is shown that these gaps must be the principal cause of the increase in strength and electrical resistivity, connected with age hardening. In order to explain the dependence of the elastic limit on the cube root of the concentration of vacant sites, as established by experiment, an atomistically inhomogeneous slip mechanism is proposed.

Part II of the paper describes an investigation of the ageing of duralumin type alloys at 160 deg. Cent. (i) directly after quenching and (ii) after initial ageing at room temperature. The results are in good agreement with the theory of vacant lattice sites developed in the first part of the paper. The filling up of vacant sites, due to self-diffusion of the solvent metal, has a decisive influence at elevated temperatures. Besides vacant sites, larger vacant regions may be formed, which are more difficult to fill ; the proportion, sites : regions, is dependent on temperature. This accounts for the restoration effects. The vacant lattice site mechanism of ageing is explained on the electron theory of metals. Vacant lattice sites are electro-negative. The larger vacant regions are electrically neutral. They may be looked upon as discharged and thereby stabilised sites. Vacant sites have therefore a pronounced effect on electrical resistivity, while the larger regions have practically no influence. This explains the decrease in electrical resistivity, observed during ageing at 160 deg. Cent.

Dr. Marie Gayler regretted having to disagree most heartily with the theory put forward in the paper. She considered the experimental evidence put forward for it as inadequate. The author had stressed the fact that previous investigators had done a good deal of analysis by means of hardness measurements, but the literature of the last twenty-five years, to which he had referred, showed that there had been X-ray analysis, density, hardness, tensile stress, and elastic limit as well as proof stress experiments, and that all those factors had been considered. Apart from that, there had been microscopical analysis. With all due respect to the author, seeing was believing. Dr. Gayler agreed that the interpretation of what one saw could be questioned, but urged that what one saw was fact. The author had totally ignored the X-ray evidence that segregates were formed in the early stages of ageing at room temperature ; he had totally ignored evidence which she had put forward concerning a change that occurred in the course of ageing at room temperature (after two years) and similarly in high-temperature ageing.

The author had started on premises which Dr. Gayler believed were quite wrong. He had talked of the diffusion and migration of atoms into the interfacial lattice space at a relatively rapid rate. So far as she

could see, however, there was no evidence of that. The work of Preston and others had shown that segregates were formed.

The author's experiments had extended over a comparatively short time. The greatest number of hours seemed to be 200; but if he had extended his experiments over a period of two years—and in that period Dr. Gayler had found quite definite signs of change in the structure and micro-structure—he would probably have found that his graphs would not have been straight lines. He had ignored data which had been established, data which was of fundamental importance to any theory of age hardening which had to do with changes in the lattice such as he suggested. Room temperature ageing could go on for hundreds of years; but at the temperature of 160 deg., with which the author had dealt, he would have obtained complete curves if he had given time. It would not have hurt to have made tests covering three years. He had not made his theory fit the facts; he had taken facts to fit the theory, which was not scientific.

Dr. W. Hume Rothery agreed on the whole that it was unfortunate that the author had ignored the experimental evidence of the microscopic work of Dr. Gayler, combined with the X-ray work carried out at the N.P.L. before the war, which was the kind of work that was really throwing light on the subject. But the author was completely right in saying that age hardening was not a simple precipitation effect. Age hardening was the first stage, which finally led to precipitation. He seemed to have made an artificial distinction when speaking of the precipitation process as being one continuous process, and the age hardening as being the result of two processes. Surely if one could take a series of instantaneous photographs of the alloy, one would see it passing through a whole series of changes, and the result of those changes would be a precipitation. There seemed to be a continual process all the time. Thus he suggested that the author's mathematics did not really support his assumptions. We needed experimental facts, not mathematical terms and vague generalisations.

Dr. T. Ll. Richards said that whilst they might not all agree with the precise nature of the physical model on which the author had based his theory, there was no denying the excellent agreement between experiment and theory with regard to the rate of change of electrical resistivity during room temperature ageing of the various aluminium alloys. He doubted, however, whether vacant lattice sites could account for age hardening, since their effect was probably only comparable to the effect of individual foreign atoms in solid solution.

After discussion of the author's mathematical theory and the results of mechanical tests, Dr. Richards said it must be realised that the theory, because of the underlying assumptions, was applicable only to the initial stages of the ageing process. The good agreement between experiment and theory in respect of the rates of the ageing process was no criterion in determining the validity of either the Röhner vacant lattice site or the Preston-Guinier zone theories. In view of the definite evidence in X-ray diffraction photographs of the existence of Preston-Guinier zones associated with hardening phenomena, the latter physical model was to be preferred, although a fully satisfactory quantitative theory had yet to be developed.

Dr. Röhner, after a brief comment on some points in the discussion, intimated that he would reply more completely in a written contribution.

Desulphurisation and Dephosphorisation of Iron

No. II—*(Continued from page 261, March 28th)*

MR. D. HOWARD WOOD, President, Institute of British Foundrymen, was in the chair during the afternoon session on Wednesday, March 19th, of the joint conference of the Iron and Steel Institute, the Institute of British Foundrymen, and the British Iron and Steel Research Association. The Third Report of the Basic Cupola Sub-Committee of the Technical Council of the Institute of British Foundrymen was presented by Mr. L. W. Bolton, Chairman of the Sub-Committee.

A synopsis of the report appears below.

REPORT ON DESULPHURISATION AND DEPHOSPHORISATION OF CUPOLA IRON AND PIG IRON IN BASIC LINED LADLES*

Using basic lined ladles and the newly developed technique of double pouring, it is possible to reduce an initial sulphur content of 0·20 per cent down to 0·045 per cent. A sulphur reduction of 75/80 per cent can be obtained consistently. These results have been obtained with metal handled in batches of five tons. The Sub-Committee believes that there need be no limit to the size of batches of metal so treated.

In investigating the desulphurisation of low silicon cast iron of the type produced from a cupola when melting 100 per cent steel scrap, it was found that treatment with soda ash removed an appreciable amount of phosphorus. Attempts have been made to increase the efficiency of phosphorus removal by the use of an oxidising agent with the sodium carbonate. In a full scale commercial trial, a low silicon cupola melted metal had its phosphorus content reduced from 0·045 per cent down to 0·036 per cent, a reduction of 20 per cent. The temperature loss in carrying out this treatment is not appreciably greater than in normal desulphurisation and the metal can afterwards be used successfully for steel making by the converter process.

Introducing the report, Mr. Bolton said that so far as the grey iron founders were concerned, except in special cases to meet low-sulphur specifications or where very poor quality scrap or coke must be used, it was unusual for desulphurisation to be necessary. Judging by the type of coke which some founders were now receiving, the question might become of greater importance in time, but generally the iron founders were not interested in obtaining the maximum possible desulphurisation.

The Sub-Committee, had been concerned more with desulphurisation as it affected the steel founder, particularly the user of the side-blown converter, melting metal from the cupola.

The producer of pig iron had also been considered, because the refined iron maker employed desulphurisation after cupola melting to supply a low-sulphur pig iron; the basic open hearth user was also interested in the removal of sulphur.

Reviewing all the evidence available, the Sub-Committee was convinced that the soda ash process would give consistent results, and that the variations sometimes experienced in practice were due entirely to lack of care and attention in carrying out the processes.

The conclusions reached were that tar-dolomite was the best material for the ladle lining, but it had certain disadvantages in use. The next best material was stabilised dolomite brick. It was possible consistently to obtain 60–65 per cent efficiency of sulphur removal, and efficiency could be improved still more by the use of the double pouring method.

With regard to dephosphorisation, work with soda ash was carried out on metal produced by melting 100 per cent steel scrap in the cupola. The Sub-Committee was aware of the work of Yocum and others, notably in the U.S.A., on the ladle treatment of metal for dephosphorisation, but that work had been concerned mainly with the treatment of very low carbon material, usually blown converter metal, and the fact that phosphorus could be removed from cupola metal containing over 3 per cent of carbon was felt to be most important. A difficulty experienced in dephosphorising blown converter metal was that temperature was lost at a time when every degree of temperature was valuable, whereas if the metal could be treated between the cupola and the converter, there was more latitude in respect of temperature.

Discussion

Mr. F. L. Robertson (John Summers and Son, Ltd.), after a reference to the chemistry of dephosphorisation and desulphurisation, pointed to the growing demand for low-sulphur steels of all grades, which, he said, was being met by foreign nations by using low sulphur, phosphorus and silicon material. They were able to do that with cheap Siemens costs, because they worked with slag weights of 8–12 per cent of their steel weight. We had an insufficient supply of low sulphur, phosphorus and silicon material in Britain to meet the demand, and our efforts to supply low-sulphur steels were made at the cost of slag weights of 20–30 per cent of the steel weight. That cost was very high, and was also on the very limit of thermal possibilities of the Siemens furnace.

The removal of the exothermal elements sulphur, phosphorus and silicon at low temperatures (say, 1400 deg.) had been proved possible by the Sub-Committee and other workers. The further work for which the Sub-Committee asked was a full-time research on how to remove those elements before the Siemens basic furnace at a cheaper cost than inside the Siemens furnace.

Mr. D. Joyce (Consett Iron Company, Ltd.), who was concerned mostly with the desulphurisation of pig iron in the blast furnace, said there was no great difficulty in desulphurising the initial high-sulphur metal down to 0·3 per cent, by using about 18 lb of soda ash per ton of iron, but with the low-sulphur iron there was great difficulty in reducing the sulphur content to low figures.

In the course of a large number of experiments on the desulphurisation of pig iron from the furnace they had had very erratic results. No doubt they were due partly to silica pick-up, but they had found also that in the soda ash reactions in the ladle there were defects. The control of the speed of transfer of the iron from the furnace into the ladle, however, played an important part; speed increased agitation in the ladle and rendered the reactions much more efficient.

In an attempt to reduce the low-sulphur hematite irons to still lower sulphur content

*Published in duplicated typescript form by the Institute of British Foundrymen, February, 1947.

they had made experiments with a 5-ton dolomite-lined ladle. The results were again erratic, but the sulphur content was reduced from 0·023 per cent to 0·009 per cent. Nobody could go near the ladle while the reaction was taking place.

Mr. Bolton said he had not had much experience of the desulphurisation of large quantities of metal. He could only point out to Mr. Joyce that, if it were possible to apply the double desulphurisation process, he might obtain more effective results than by pushing up the quantity of soda ash used to high figures.

Silica Contamination

Mr. N. L. Evans said that under the conditions obtaining in the foundry or at the blast furnace the metallurgist could not usually control the variables with the degree or accuracy possible to the chemist working in his laboratory. But there was much that could be done, and recent improvements in the sodium carbonate treatment of iron had been dependent on the elimination as far as possible of variables.

The most serious contaminator of soda slag was silica. Most ladle refractories were siliceous in character, and were attacked by alkaline slags. Such attack was at its maximum with a new lining, and became slower when the lining became impregnated with alkaline slag and coated with a glaze. It was greater with a rammed lining than with one constructed of fired bricks. Speaking broadly, with ladle linings made of the ordinarily available siliceous refractories, and using 1 per cent of sodium carbonate, 50 per cent of the sulphur initially present in the molten iron could be removed.

The use of the various basic ladle lining materials available had vastly improved the efficiency of the sodium carbonate treatment by minimising the adulteration of the soda slag with silica. Results were being obtained with rammed linings of tarred calcined dolomite, and in one foundry an average sulphur reduction of 70 per cent was obtained.

One serious limitation of tarred dolomite linings, however, was that they hydrated when exposed to the atmosphere. Some degree of protection against that was afforded by the impregnation of the surface layer of the lining with soda slag; but it was important that the linings should be kept hot. They were suitable, therefore, for use in converter steel foundries for the desulphurisation of cupola iron, which was normally dealt with in batches at about half-hourly intervals, and they should be kept hot overnight and at week-ends.

When it was not possible to observe that condition, it was recommended that fired stabilised dolomite bricks be used for the lining, but even the comparatively small silica content of those bricks had a slightly adverse effect on the desulphurising reaction.

Practice in the Saar

Dr. T. P. Colclough (Iron and Steel Board), who commented that it was just as well to keep separate the two problems of desulphurisation and dephosphorisation, said that in desulphurisation perhaps the fundamental factor was contact between the reacting bodies; that was far more important than temperature or the proportion of soda ash used.

Expressing a little surprise that the report did not refer to work which had been done in circles outside the Sub-Committee, he said he believed it was at least twelve years since the Germans had originated really large-scale desulphurisation, in the Saar. The pig iron made there was of exceptional characteristics, in so far as the temperature was too low to permit of the addition of any solid reagent to the metal. So the soda ash was melted in a small rotary furnace and the liquid soda ash was allowed to trickle into the iron stream as it came from the end of the runner into the ladle. The amount of contact obtained by a small liquid stream, like a pencil, falling into a ladle of liquid pig iron was far too small to give an efficient reaction. Therefore, they had constructed a brick "tea-pot" ladle, which was the real origin of the double pouring method that was introduced later into this country. The metal was handled in 60-ton ladles. The pig iron ladle was picked up by crane and the contents poured into the brick vessel, which already contained some metal with slag on the top. The pig iron and soda slag was churned up, it went out through the spout and into a second ladle, and as it came out through the top the used soda slag ran off. In that way they had effected desulphurisation to the extent of about 70 per cent, which was similar to that effected in works E in the report.

Commenting that we talked very glibly of desulphurisation efficiencies of 50 and 70 per cent, Dr. Colclough pointed out that for very many years we had been desulphurising in basic lined ladles holding 400 tons; they were nothing but hot metal mixers. The metal was allowed to stand in a dolomite-lined basin and 50 per cent of the sulphur was eliminated without adding anything.

The efficiency of the soda ash process should be measured not merely by the amount of sulphur removed, but by reference to the amount of sulphur removed by the soda ash used as compared with what ought to be used. 100 lb of soda ash ought to remove 30 lb of sulphur. With the very good normal practice at works E, mentioned in the report, the efficiency of the soda ash was 33 per cent. Coming to the double pouring method, taking the average of the cases reported, the first dose of soda ash gave 21 per cent efficiency, the second dose gave only 6·4 per cent efficiency, and the average for the whole was 13·6 per cent efficiency. In other words, seven times as much soda ash was used as ought to have been used. That was a serious matter.

Mr. E. T. Gill (Edgar Allen and Co., Ltd.) confirmed and affirmed the point made by Mr. Evans that the conditions under which desulphurisation was operated must be kept constant. His firm had been undertaking the process for nearly three years, and on occasions there were rogue results, but they could always be traced to some fault in the working of the process and were not due to the process itself fundamentally.

Mr. Bolton agreed that, so far as the Sub-Committee's work had proceeded, the most effective dephosphorisation was obtained only in the absence of silicon, and it was necessary to re-siliconise in order to ensure a successful converter blow in the normal operation of the side-blown converter. He believed that under good working conditions the metal should have sufficient temperature to take in the required silicon and still give a good blow. But he appreciated that those conditions could not be maintained indefinitely in the average steel foundry, and that the problem required solution.

Mr. N. L. Evans stated that the use of the "teapot" ladle was not referred to in the report because it was published in this country comparatively recently. But we had not to suffer from the inferiority complex by thinking that the double pouring method of desulphurisation had its origin in Germany because that was not the case. A good deal more than twelve years ago it was in operation in this country at a steelworks making silicon steel, where a low-sulphur content was necessary, and that was effected in ladles of between 50 and 70 tons capacity. The double pouring technique, he believed, was used originally in Great Britain.

Mr. R. D. Dick (Pease and Partners, Ltd.), bearing out Mr. Evans' remarks on the use of soda ash and burnt lime as a desulphuriser, said that bad effects had been obtained in small amounts of iron, up to 4–5 tons, poured from the cupola into a receiver. The iron, instead of having a close-grained cylinder-iron type of fracture, was pitted with what were more or less gas holes.

He suggested also that the shape of the container had something to do with the efficiency of desulphurisation in small amounts of metal. For instance, if the metal were poured into an ordinary 5-ton foundry ladle with, say, 1 cwt of soda ash as desulphuriser, the action was more or less quiet. On the other hand, when the soda ash was put into the bottom of a receiver about 15ft high and 2½ft in diameter and the metal was poured on to it, the action was very vigorous indeed. A long flame came out at the top and the desulphurising was much more efficient in that type of receiver than in an ordinary foundry ladle.

The chairman said that references had been made to impressing upon the Government the urgent need for more supplies of soda ash. He did not know whether it was possible for those concerned to use their influence with the Government to take the necessary steps.

Dr. A. H. B. Cross (Thos. Firth and John Brown, Ltd.), referring to the breakdown of soda ash, said the sodium oxide which ultimately achieved desulphurising did not necessarily do it wholly through the medium of sodium sulphide. Examination of the new soda ash slags showed not only sodium sulphide but also sodium sulphate and sodium sulphite. So that the actual mechanism of desulphurising was perhaps a good deal more complicated than was normally stated.

Collation of Research Work

Dr. Colclough, pointing out that a great deal of work was being done in various directions, that there never had been before a time of such great activity in the industry, and that funds were being made available for research work, was anxious to ensure that the results of the work were being collated and put across to the industry for application. He urged that it would be valuable if the various committees concerned would get together and evolve simple working rules whereby the best possible results could be obtained from the application of the knowledge we had gained. The Institute of British Foundrymen, the Iron and Steel Institute, and the British Iron and Steel Research Association might perhaps issue booklets from year to year, giving the results that had been obtained for the benefit of all in the industry.

American Steel Industry Development.—It is announced that steel companies in the U.S.A. plan to spend 448 million dollars in the present year on new equipment and development work. A large portion of the expenditure is to be devoted to expanding the industry's capacity for sheet and strip steel.

Marine Submersible Centrifugal Pump

DURING a recent visit to the works of Worthington-Simpson, Ltd., at Newark-on-Trent, we saw under construction and on test several examples of a recently-developed submersible centrifugal pump for marine service. Pumps of this design played an important part during the war years in maintaining pumping capacity unimpaired under the most difficult conditions in naval and mercantile ships.

A descriptive account of this pump will be of interest to our readers. It is about ten years since the design and research staff at Worthington-Simpson's works began to study the fundamental characteristics for a new range of pumps. In 1936 the first of a series of patents was granted to the company, all of which have been used in the development of a submersible, automatic, self-priming pump, which has appropriately been styled the "Numarine" pump.

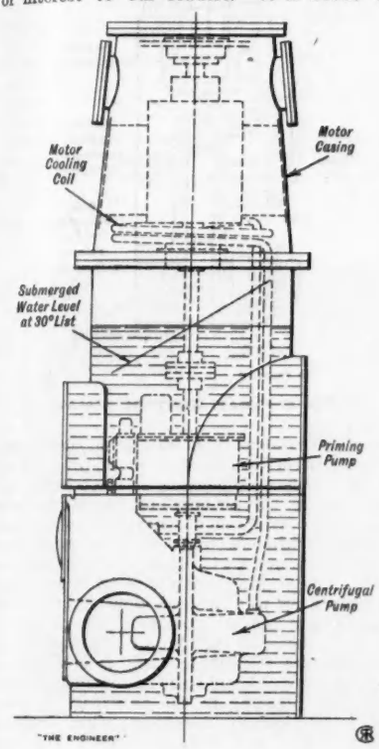


FIG. 1—DIAGRAMMATIC ARRANGEMENT

The design was originally evolved in order to meet the demands of the Board of Trade, the classification societies and the Admiralty for pumps for emergency, fire, bilge and ship salvage purposes. In particular, during the war, damage control schemes formed an integral part in the operation of capital ships, and the new pump found applications in battleships, cruisers and aircraft carriers, also in cargo and passenger ships, in units with capacities ranging from 50 up to 550 tons per hour. In naval ships these pumps are fitted throughout the ship so as to form a complete damage control system, the electrical driving power being supplied from generators in different parts of the vessel, so that in an emergency there can be no failure of supply. In merchant ships it is the usual practice to install the submersible pump either in the engine-room or at the entrance to the shaft tunnel, and to supply the power from an oil engine driven generating set arranged at some point outside the machinery spaces, so that, if necessary, the pump can be worked in a flooded engine-room.

General Design

The distinctive design adopted can be clearly followed from the diagrammatic drawing and the two engravings reproduced in Figs. 1, 2 and 3. The unit consists of a vertical shaft centrifugal pump with a water-ring air exhauster or priming pump arranged above the main centrifugal pump, both pumps being driven by an electric motor, completely enclosed in an airtight and watertight casing. For the general structure of the whole unit a tubular form was chosen, which, while light and strong, has a low overall height and weight. The pump can thus be installed in compartments with restricted headroom and, while it is totally enclosed, it can nevertheless be readily examined or dismantled and reassembled in a confined space.

The drawing reproduced in Fig. 1 shows the general principles of construction. The motor casing and its circular supporting base are made perfectly airtight, so that, when the unit is submerged, air is entrained in the motor and casing and is compressed in the upper part. Water is thus kept a safe distance below the working parts of the motor. The submerged level is indicated on the drawing. The design is such that submergence up to 40ft is permitted, together with a list, or angle of tilt, up to 30 deg. The priming pump with its water tank and control valve is mounted between the centrifugal pump and the driving motor. The motor is cooled by circulation of air, which is produced by the special formation of the armature coils, while water cooling coils are also placed in the base of the motor casing. These coils are designed to keep the temperature of the motor windings within normal limits, even under the most severe tropical conditions. The method of cooling, it is claimed, reduces the amount of air needed to a minimum and at the same time keeps down the size and bulk of the motor and its supporting casing. The motor was designed in conjunction with the Electro-Dynamic Construction Company, Ltd., of Orpington, Kent.

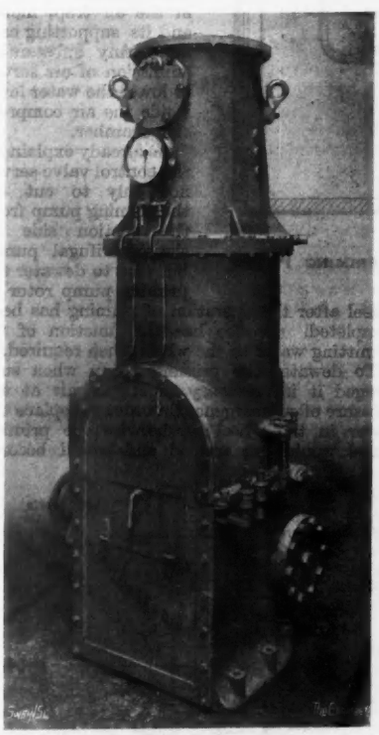


FIG. 2—PUMP UNIT

The assembled pump is illustrated in Fig. 2. Its neat and clean appearance may be noted and its freedom from all protuberances. The only external pipes are those for the pressure gauge. Above the gauge there is mounted an inspection door, which gives access to the motor commutator and brushes. At about the same level are two lifting eyes. Lower down the pump on the right-hand side are the two lubricating fittings for the pump bearings. These are the only parts requiring attention, apart from the usual care bestowed upon the centrifugal pump gland.

An interesting point is the provision for airtight testable joints between all necessary pump parts. The main joint on each of these surfaces has a central recessed groove, which is connected to a normally closed screwed nipple. By attaching a gauge fitting with a connection for a common bicycle pump a few strokes of the pump are used to establish a pressure, which, if maintained unaltered over a period of twenty minutes, is considered satisfactory. Easy access is given to the pump gland through the hinged door on the front of the pump. The bottom half of this door does not have to be watertight, as its purpose is merely to keep the inside of the pump casing free from vermin and floating rubbish and, at the same time, to strengthen the structure as a whole. Alternative suction branches on each side of the pump are provided, to which the air separator is attached in a convenient manner. Reference to the design of the separator will be made later on.

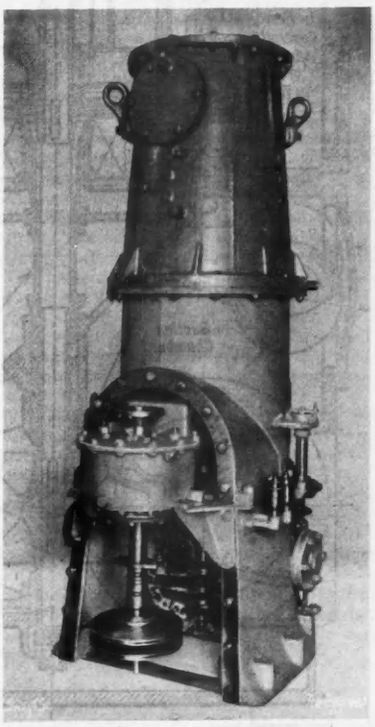


FIG. 3—REMOVAL OF IMPELLER AND PRIMING PUMP

Easy access to the centrifugal pump impeller, the priming pump and the shaft is given when the door is removed, and, as shown in Fig. 3, these parts can be withdrawn through the door opening for inspection without having to disturb either the motor or its airtight casing. From the same illustration it can be noted that provision is made for the pumps and shaft to be drawn forward as one unit. All that is necessary for this operation is to remove the front half of the centrifugal pump casing and the bolts in the coupling.

Centrifugal and Priming Pump Design

The drawing we reproduce in Fig. 4 shows the design and arrangement of the centrifugal and priming pumps, the size of pump illustrated being one with a capacity of 350 tons per hour, delivered against a head of 50ft. The centrifugal pump has a double entrance impeller, with bearings above and below it to ensure rigidity, long life and high efficiency. In the suction

chamber, well above the impeller, is a float which controls a vacuum valve. The duty of the vacuum valve is to open and close the suction passage between the priming and centrifugal pumps. The stem of the float valve is used to control ports which dewater the priming pump when the operation of priming is completed. Alternatively, the stem of the valve also uncovers ports which allow the priming pump to be filled with water from the reservoir as required. Access to the float is readily obtained by means of the door adjacent to it, as shown.

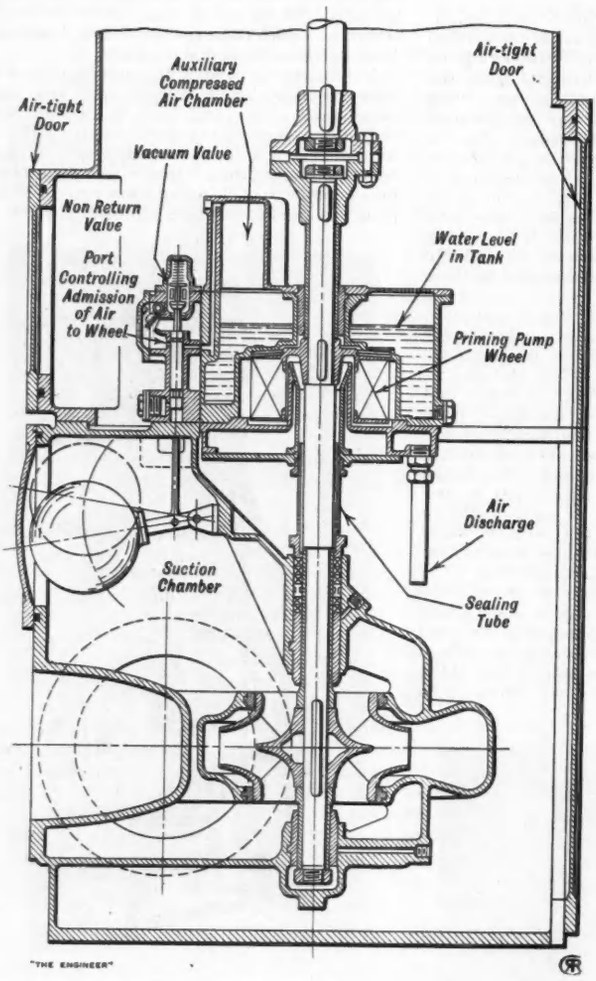


FIG. 4—SECTION THROUGH CENTRIFUGAL AND PRIMING PUMPS

The pump casing and the priming pump are bolted and spigoted together, which ensures that the pump and motor retain concentricity after dismantling and reassembly. Some of the advantages conferred by locating the priming pump in this way are as follows :—The priming pump is brought as near as possible to the suction of the centrifugal pump. No connection is needed between the priming pump and the float and suction chambers, all air passages being cast into the structure. The valve controlling the priming pump is as near as possible to the priming pump wheel, which again eliminates all piping and connections, other than bolted joints.

By using a small bronze tank for the priming pump sealing water, which, it will be noted, is cast in one piece with the body of the priming pump, a single casting is obtained.

It will be recalled that the priming pump and its control valve may have to operate at angles up to 30 deg. in any direction, and it is therefore desirable that the water in the tank tilts about the shaft centre. The size of the tank must be kept to the minimum necessary consistent with its capacity to hold sufficient water to seal the priming pump. The tank contains about 1 gallon of sealing water and in service it seldom requires replenishing.

Another advantage of the priming pump being arranged within the main structure of the pump unit is that it permits of a simple form of unloading or dewatering device, both in the non-submerged and submerged conditions. We noted that the dewatering device is in the form of a relatively small and neat assembly, which requires little or no attention and has practically no wearing parts.

A notable point in the design of the priming pump is that it has no shaft stuffing-box. The vacuum side of the pump faces downwards towards the centrifugal pump gland, and by extending this gland in the form of a tube surrounding the shaft a stationary and non-wearing seal for the priming pump is obtained. The arrangement has the further advantage that any leakage from the centrifugal pump gland passes up the tube into the priming pump through its wheel, and so to the tank, thereby replenishing the tank with filtered water.

It may be observed that air extracted from the suction lines to the main pump is discharged inside the air compression chamber, thus replenishing the air in the air trap, motor and its supporting casing. Any substantial admission of air serves to lower the water level inside the air compression chamber.

As already explained, the control valve serves not only to cut off the priming pump from the suction side of the centrifugal pump, but also to dewater the priming pump rotor or wheel after the operation of priming has been completed. It also has the function of re-admitting water to the wheel when required.

To dewater the priming pump when submerged it is necessary to supply air at the pressure of submergence, in order to replace the water in the wheel; otherwise the priming wheel would not unload and would become waterlogged, a condition in which the power absorbed by the priming pump would be doubled. It is not desirable to use compressed air from the air trap of the motor for unloading the priming wheel. An auxiliary air chamber is formed on the top of the priming pump tank, and under conditions of submergence air is compressed in this chamber to the same pressure as in the air trap, thereby equalising the pressure at the inlet and outlet of the priming wheel. Consequently the operation of unloading the wheel is unaffected and the compressed air in the auxiliary chamber fills the space vacated by the water in the wheel, allowing the priming wheel to run in compressed air in the submerged condition, as it runs in atmospheric air in the non-submerged condition.

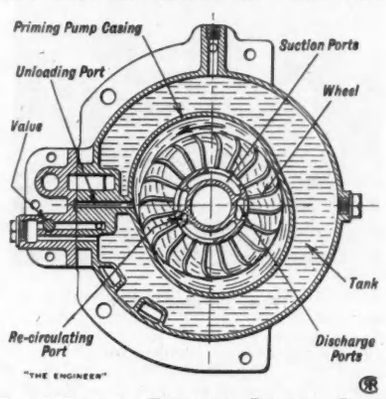


FIG. 5—SECTION THROUGH PRIMING PUMP

In Fig. 5 we show a section through the priming wheel and the reservoir. It will be seen that the wheel is double acting, there being two eccentric spaces in the priming pump casing. This arrangement, it is claimed, not only doubles the air-handling capacity of the pump for a given size of wheel, but it balances the forces within the wheel, with the result that no bending moment is imparted to the driving shaft. The priming pump is designed to create a vacuum up to 27in and, depending on the size of pump unit, it is designed to handle from 15 to 35 cubic feet of free air per minute. A generous size of priming pump is desirable to deal with possible air leaks in the suction lines and valves leading to the centrifugal pump; this is particularly necessary when draining tanks, bilges and compartments. For test purposes the priming pump is designed to handle the leak through a 5 mm nozzle into the suction line, while maintaining a vacuum of 25in with only a 5 per cent drop in the amount of water discharged by the centrifugal pump.

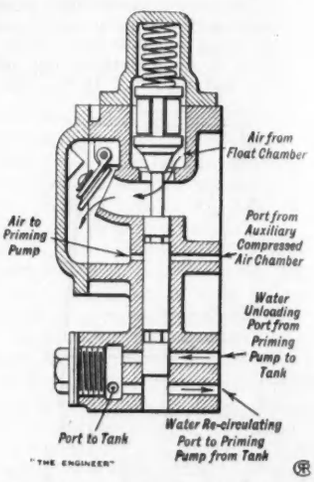

Air from Float Chamber
Air to Priming Pump
Port from Auxiliary Compressed Air Chamber
Water Unloading Port from Priming Pump to Tank
Port to Tank
Water Re-circulating Port to Priming Pump from Tank
"THE ENGINEER"

FIG. 6—FLOAT CONTROL VALVE

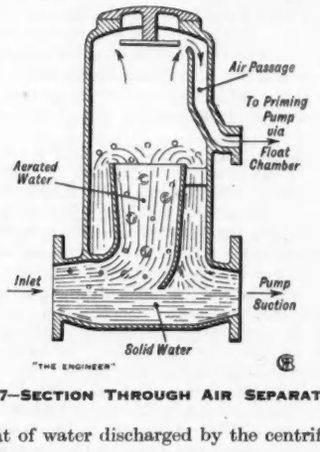


FIG. 7—SECTION THROUGH AIR SEPARATOR

In Fig. 5 is shown also the unloading port for dewatering the pump after the operation of priming is over. By means of cross passages in the valve box (see Fig. 6) this unloading port is also connected across the valve stem to the reservoir. The drawing reproduced in Fig. 6 shows in diagrammatic form the valve and spindle and the arrangement of the ports. The valve is shown in its up position with the float down, indicating air in the suction chamber. It will be seen that in this condition the unload-

ing ports are closed by the valve stem and the recirculating ports are open, providing sealing water for the wheel of the priming pump. When the valve is in the down position the recirculating water is cut off and the dewatering ports opened, permitting the water inside the priming wheel to be transferred by centrifugal force into the reservoir tank. In the submerged condition with the valve down, air is taken from the auxiliary air chamber, shown in Fig. 4, to the inside of the wheel, replacing the water which is discharged by centrifugal force to the surrounding tank or reservoir.

Air Separating Chamber

We reproduce in Fig. 7 a section through the air separator, to which brief reference has already been made. This separator can be fitted to either side of the pump to suit any pipe arrangement, the unused suction flange being blanked off. The purpose of the fitting is to separate as far as possible air from the incoming water before it enters the suction and float chamber of the centrifugal pump. For practical purposes it can be assumed that about one-third of the water travelling along the bottom of the suction pipe will be fairly free of air, but that in all probability two-thirds of the water will be aerated. As is shown in the drawing, the solid water is allowed to pass straight

Fig. 8—Testing Tank for Marine Pumps

through into the suction chamber of the pump and the remaining two-thirds is spilled over a weir, the entrained air being liberated at the top of the separating chamber. A further separation of air actually takes place in the float chamber itself; thus the impeller of the centrifugal pump is supplied with solid water, even if there are very large permanent air leaks in the suction line to the pump.

In the testing department we saw pumps running under test conditions, and noted that all pumps of this class are tested under actual submerged conditions for a period of from six to twenty-four hours before dispatch. The way in which the priming pump immediately deals with large air leaks was demonstrated to us. We illustrate in Fig. 8 the special tilted test tank employed, which was constructed to accommodate a wide range of pumps. The pump to be tested is placed inside the tank, in which a pressure of water equal to the depth of submergence is artificially maintained. The water level inside the motor casing is shown on a water level gauge on the outside of the test tank, and evidence of the effect of air leakage into the pump suction is shown on the gauge by the depression of the water level in the motor casing.

In inspecting the various pump parts going through the shops we noted evidence of high-quality materials being used and excellent workmanship. All the rotating parts are dynamically balanced and metal spraying with cadmium is employed to protect steel fabricated parts from corrosion. Of the submersible pump we have described, about 500 units have been supplied, all of which, we were informed, have given satisfactory service. It is of interest to record that submersible pumps of this design have been fitted in the battleships H.M.S. "Vanguard" and "King George V" and in the aircraft carrier "Ark Royal," and that they are being installed in all the new ships of the Blue Funnel Line.

Interim Statement on the Economic Outlook*

The Government should ensure that activities which are adjudged essential as short-term objectives shall be fully—and continuously—supplied with their needs in fuel and materials, while other activities or projects, whether productive or non-productive, are cut back.

The target for coal should be increased to 220 million tons. The National Coal Board should be urged immediately to take all possible steps to improve coal washing facilities, and otherwise to improve the quality of coal delivered.

Efforts should be made to import 10 million tons of coal, without reducing the quantities being shipped for the relief of Europe.

The export of coal cutting and other mining machinery needed for home use should be critically re-examined.

The coal distribution plan already announced should be so operated that the extra amounts to be allocated, whether handled regionally or otherwise, are guaranteed amounts, and that the principle is observed that production considered to be most vital shall receive 100 per cent of its needs.

Resources for building power stations and manufacturing their equipment should be mobilised, guaranteed their necessary supplies, and set a programme based upon a two-year construction interval.

To meet the emergency, new designs for power station equipment should be deferred and replicas of existing stations reproduced to save time.

The export of power station equipment needed for home use should be critically re-examined.

The importation of power station equipment from Germany should be examined. This form of emergency assistance should not be rejected merely because special power stations may be needed to accommodate the equipment; they should be constructed and, if necessary, German specialist labour brought over to erect the plant. All other possibilities of importation should also be exhaustively surveyed.

The arrangements for any necessary load shedding should be organised so that industrial undertakings may know the particular days on which their own turn for shedding may come.

A balance must be struck between supply and demand for steel. After increasing supply to the maximum possible, the method of securing this balance should be by reducing the amounts allocated to less essential parts of the programme. If the export and capital equipment targets cannot be reached in any other way, it may even be necessary to reduce the housing programme still further than is suggested in the White Paper.

The Government should publish figures showing the allocations, for a range of periods, of steel and other basic raw materials to the different categories of end products. Secrecy about this vital element in the programme can no longer be justified.

Unremitting efforts should be made to increase the supply of critical materials. There is grave risk of expansion of supply taking second place to the solving of distribution problems.

The building and repair of locomotives and wagons for the home railways and the renovation of the permanent way should be among the objectives to be maintained at maximum activity. Plans should be prepared and carried out for the relief of these and any other main bottlenecks in the railway system which are repeatedly the cause of embargoes and delays.

Parliament and industry should be enabled to concentrate upon the economic and production problems of to-day and be relieved of the necessity to direct their thoughts and energies on to controversial issues that can be deferred.

Incentive should be increased to all grades by a reduction in direct taxation.

Consultation with industry should be maintained to keep a constant watch upon the export of capital plant. The conflict between the capital equipment and export targets should be resolved. In certain cases, notably rail transport re-equipment at home should be given priority over export.

The Government should collaborate with industry to ensure that the production of capital plant for the industries adjudged to be of greatest importance should take precedence over that for other industries, which may in any case not be able to operate at full activity.

There should be regular and continuing consultation with different industries in order to maintain a constant watch on their ability to continue selling fully manufactured goods, with an adjustment of policy when this may be found necessary.

A discriminating use should be made of indirect taxation to counterbalance the inflationary effects of reducing direct taxation.

The present policy of progressively reducing the rate of interest paid by the Government on savings should be brought to an end. In the case of small savings it should be reversed to encourage a greater willingness to save and so accelerate the absorption of surplus purchasing power.

No opportunity should be lost of getting rid of any one of the controls; the price mechanism which is the alternative should be allowed to act at the first possible moment.

The Government should modify necessary surviving controls so as to make it possible for applicants for licences, &c., to clear all the necessary steps through the single department principally concerned. Where necessary, representatives of other departments affected should be boarded out with the departments principally concerned, to take the necessary decisions.

Conclusion

We have indicated in this interim statement certain of the steps which should now be taken in the present emergency. We have not failed to emphasise our view that our present unbalanced economic situation is critical in the extreme. At the same time, it is our firm belief that resolute action now coupled with an all-out effort on the part of every individual in this country to pull his full weight, whatever his job, can and will make our future secure.

In all that we have said we have shown that we accept the necessity for our national economy to conform to an overall plan. Indeed, in some directions we have suggested additional planning to meet the emergency of to-day. But the idea that a central plan can be enforced by a host of detailed controls is false. It will not work. A technique must be developed by which the responsibility for carrying the broad plan into effect is diffused through industry.

We believe that our future as an industrial nation depends on hard work, perseverance, initiative and enterprise. The greatest need to-day is to establish confidence that any plan announced is based on realism, and that resources allocated can be guaranteed.

* Recommendations and conclusion from a Statement by the Federation of British Industries.

The Presentation of Technical Information—A course of four lectures on "The Presentation of Technical Information" is to be given by Professor R. O. Kapp at University College, Gower Street, London, W.C.1, on Fridays, April 25th, May 2nd, 9th and 16th, at 5.45 p.m. The first lecture will be introductory, and subsequently Professor Kapp will deal with the parts played by psychology and logic in presentation, pointing finally to some specific problems including care in the use of words.

Metallurgical Topics

Temper-Brittleness in Alloy Steels

THE extensive investigations on temper-brittleness which were made in the first World War gave much information about conditions under which it developed and means by which it could be controlled, but the cause of temper-brittleness and the essential character of the phenomenon remained conjectural. Since then, as Mr. Harry Brearley, himself a pioneer investigator of the subject, has recently remarked, "The causes and effects of temper-brittleness represent one of the standing subjects for researchers who may be short of employment. It pops up regularly in technical journals, and dies down again without adding much to the little already known." The subject has certainly been brought to the fore again in the second World War, and has formed the subject of numerous papers in France and America. It would clearly be unjust to say that these papers add but little to the general knowledge of the subject, though it can safely be asserted that much of the experimental work is confirmatory of what was already known or could readily be deduced from earlier work, and agreement as to the cause of temper-brittleness seems to be as remote as ever. In assembling the data to form a fresh starting-off place for new investigations, Mr. J. H. Hollomon[1] has done a valuable piece of work.

IMPORTANCE OF TESTING TEMPERATURE

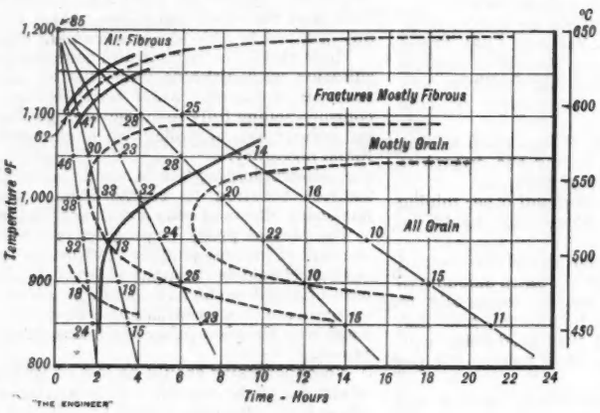
One important modification of the viewpoint from which temper-brittleness has come to be regarded arose from the work of H. Jolivet and G. Vidal[2], who emphasised the possibly misleading indications of a "susceptibility ratio" based on results of impact tests made at atmospheric temperature only, and showed that an apparently non-susceptible steel might be affected by temper-brittleness, revealed at some lower temperature by a difference between the impact values of the steel rapidly cooled after tempering and of the same steel either slowly cooled or reheated within the embrittling range. In other words, the criterion of temper-brittleness was not the susceptibility ratio as formerly understood, but the temperature-displacement of the impact figure/temperature curve.

This conception has given rise to a considerable amount of re-evaluation of the data of temper-brittleness by the aid of tests made over a range of temperatures or at a particular temperature which is critical for the steel being tested.

It was with this as a basis that W. S. Pellini and B. R. Queneau[3] embarked on the study of the development of temper-brittleness in two basic open-hearth, aluminium-killed steels of the following composition :—

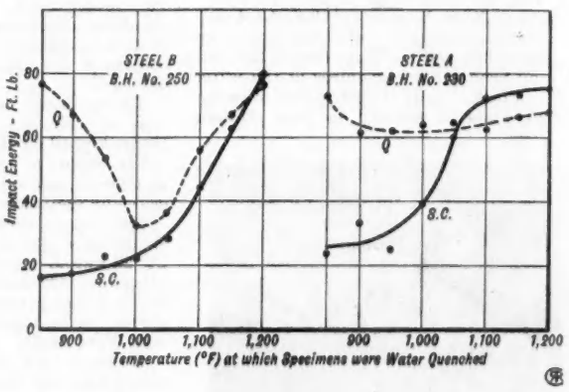
	Steel A	Steel B
Carbon	0·33	0·44
Silicon	0·06	0·06
Manganese	0·23	1·64
Sulphur	0·021	0·022
Phosphorus	0·013	0·029
Nickel	3·78	1·84
Chromium	1·79	1·64
Molybdenum...	—	0·40
Vanadium	—	0·15

The notched-bar tests were made on longitudinal test-pieces with a 45 deg. V-notch, 2 mm deep, root radius 0·25 mm. Steel A would have given only a very slight indication of temper-brittleness if the impact tests had been made at atmospheric temperature (see Fig. 4), but the effect was evident in tests made at —50 deg. Cent.



The changes in mode of fracture for samples cooled from 1200 deg. Fah. (650 deg. Cent.) are represented by the three solid curves, whereas the three dotted curves represent the corresponding changes in mode of fracture of the isothermally treated samples. Temperature of test —50 deg. Cent.

FIG. 1—*Effect of Rate of Cooling on Development of Temper-Brittleness in Steel B.*



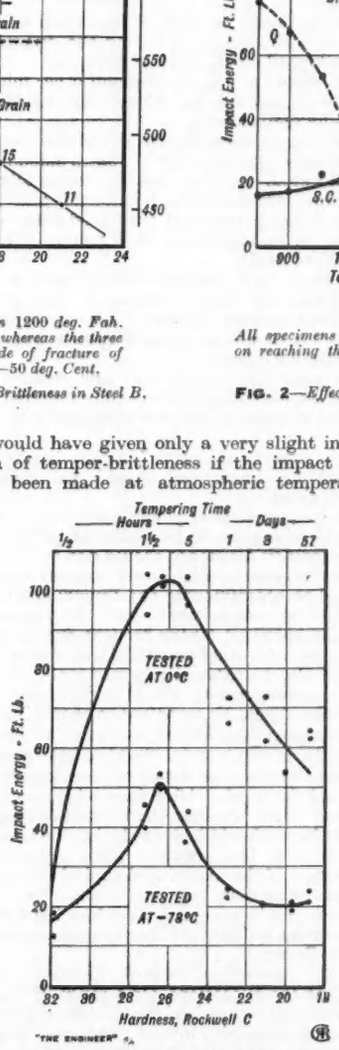
All specimens were heated at 50 deg. Fah. per hour and water-quenched on reaching the temperatures indicated. Temperature of test —50 deg. Cent.

FIG. 2—*Effect of Continuous Heating through the Temper-Brittle Range.*

ISOTHERMAL TREATMENT AND CONTINUOUS COOLING

The influence of time at temperatures within the embrittling range was determined and the results compared with the brittleness developed in the steels when cooled through the same range of temperature. For steel A the times and temperatures required to develop temper-brittleness were approximately the same whether the embrittlement was induced isothermally or during continuous cooling. Steel B, however, showed embrittlement more rapidly on continuous cooling than when held at constant temperature in the temper-brittle range. Results are shown in Fig. 1. The authors attach great importance to the type of fracture which is indicated in detail in the original diagrams, but only the approximate boundaries of the different regions are given in that reproduced here.

In steels which show any appreciable susceptibility the more pronounced effect of continuous cooling would be expected since prolonged heating at the temperature which gives the maximum rate of embrittlement does not produce the minimum impact figure; this falls only to an intermediate equilibrium value, which is the same as that reached on reheating an embrittled specimen at the same temperature[6]. As the authors clearly indicate, the rate of embrittlement shown is affected by the temperature at which the impact tests are carried out. An increase in testing temperature will have the effect of decreasing the apparent rate of embrittlement, whereas a decrease in testing temperature will have the reverse effect. For example, in Fig. 1 a test temperature of 0 deg. Cent. would have shifted the "fracture" curves to the right and little indication of temper-brittleness might have been found, except at very slow rates of cooling.



All specimens were water-quenched from 900 deg. Cent. and tempered for the times indicated and water-quenched. Composition :—Carbon 0·09, manganese 4·53, silicon 0·12, molybdenum 0·93 per cent.

FIG. 3—*Effect of Tempering on the Impact Energy of a High-Manganese-Molybdenum Steel.*

The effect of reheating tough and brittle specimens of the same steel continuously through the embrittling range was determined. The rate of heating was 50 deg. Fah. per hour, the specimens were withdrawn and water-quenched at intervals of 50 deg. from 850 deg. to 1200 deg. Fah. (450 deg. to 650 deg. Cent.) and were broken at —60 deg. Fah. (—50 deg. Cent.). The greater susceptibility of steel B is evident in Fig. 2, in spite of the presence of molybdenum, which is not effective in suppressing temper-brittleness in the presence of such a high manganese content[7].

The data obtained by Pellini and Queneau have led them to the following conclusions :—

"(*a*) The maximum rate of embrittlement occurs at about 950 deg. Fah. (510 deg. Cent.).

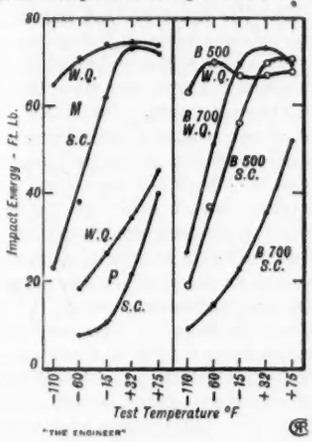
"(*b*) Embrittlement occurs at temperatures as high as 1200 deg. Fah. (650 deg. Cent.).

"(*c*) The transformation causing embrittlement in alloy steels is a reversible reaction.

"(*d*) A steel having a tempered martensitic structure is somewhat more susceptible to

temper-brittleness than the same steel having a pearlitic microstructure."

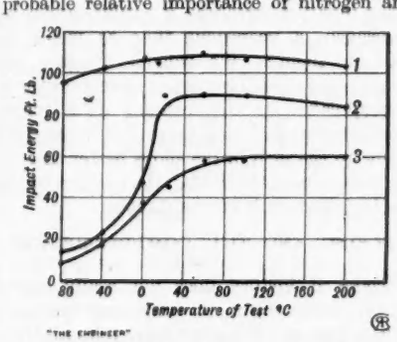
The first of these conclusions is entirely in line with previous experience, all investigators giving temperatures of from 500 deg. to 525 deg. Cent. for maximum rate of embrittlement. The view that the embrittling effect is due to a reversible reaction, involving precipitation and re-solution, is well supported by earlier work, as also is the conclusion that temper-brittleness develops most readily in a steel in the fully-hardened and tempered condition. The embrittlement reported to take place at 650 deg. Cent. (Fig. 3) occurred in a steel of exceptional composition; the form



All samples tempered at 650 deg. Cent. and either water-quenched (w.q.) or cooled at 50 deg. Fah. per hour (s.c.) after tempering. M. *Oil-quenched, martensite, B.H. No. 230;* P. *Transformed at 600 deg. Cent., pearlite, B.H. No. 200;* B500. *Transformed at 500 deg. Fah. (260 deg. Cent.), bainite + 60 per cent martensite, B.H. No. 230;* B700. *Transformed at 700 deg. Fah. (371 deg. Cent.), bainite + 10 per cent martensite, B.H. No. 220.*

FIG. 4—*Effect of Microstructure on Development of Temper-Brittleness in Steel A.*

of the curve is similar to that for the more usual temper-brittle steels, when given an initial tempering at 520 deg. Cent., but until more is known of the carbide and nitride eutectoid temperatures in steels of the type to which Fig. 3 refers, it is perhaps premature to base on this observation (as the authors do) a criticism of Hollomon's assessment of the probable relative importance of nitrogen and



1. *Tempered Martensite;* 2. *Tempered Martensite + Bainite;* 3. *Tempered Martensite + Pearlite.*

FIG. 5—*Impact Properties of Steels of Various Structures at a Tensile Strength of 56 Tons per Square Inch.*

carbon as the element responsible for the precipitation giving rise to temper-brittleness.

Investigation of Microstructure

A considerable amount of work will still be necessary before agreement can be reached on the exact cause of temper-brittleness, but the discovery of an etching reagent which will reveal the temper-brittle condition is a valuable achievement[4]. The preparation of the solution and the etching technique are fully described. Though the essential addition to the normal picric acid reagent is an American proprietary antiseptic and bactericidal substance, the description given shows that it is one of a class of quaternary ammonium salts known to be cation-active wetting agents. There is no reason to suppose that other high-alkyl quaternary ammonium salts like cetyltrimethylammonium bromide, or even other types of the same class of wetting agents, such as cetylpyridinium chloride, may not be equally effective. The micrographs illustrating the paper give a clear indication of the grain-boundary precipitation which gives rise to embrittlement, and encourage the belief that a valuable technique for the investigation of grain-boundary phenomena has been introduced.

Effect of Microstructure on Properties

Pellini and Queneau make a brief reference to the effect of microstructure on susceptibility to temper-brittleness. Specimens were prepared by oil-quenching from 900 deg. Cent. (martensite) and by interrupted cooling with isothermal transformation at 260 deg. to 410 deg. Cent. (bainite + martensite), and at 600 deg. Cent. (pearlite). They were all subsequently tempered at 650 deg. Cent. A few typical curves are reproduced in Fig. 4 from the diagram of results given for Steel A. The tempered martensite structure possessed the highest energy absorption in the notched-bar test. The tempered bainites formed at low temperatures have properties approaching those of the tempered martensite, while bainite, formed at high temperatures, and pearlite have a much lower impact value. A small amount of pearlite has a markedly deleterious effect on the toughness of a tempered martensitic matrix.

The effect of microstructure has been dealt with in more detail by J. H. Hollomon and his co-workers[5], whose wartime experience at Watertown Arsenal has convinced them that steels having a tempered martensite structure have mechanical properties superior to those of steels with any other structure. They found that impact values of tempered bainitic steels were intermediate between those of tempered pearlitic and tempered martensitic steels of the same hardness (Fig. 5), and that the ductility of the steel, as measured by reduction of area for a given tensile strength, and its yield ratio were inferior to those of tempered martensite. This is confirmatory of the work of Griffiths, Pfeil and Allen[6], who showed that transformation of austenite at temperatures of 350 deg. to 450 deg. Cent. gave rise in the tempered steel to elastic properties, ductility and impact value inferior to those shown by tempered martensite.

Pellini and Queneau rightly stress the importance of the study of temper-brittleness if maximum properties are to be developed in steels used in heavy sections, but some exception may be taken to the statement that "temper-brittleness, instead of hardenability, will determine the alloy content of steels used in large sections." Excessive hardenability is bad, but the properties of tempered martensite are so superior (at the same level of tensile strength) to those of steels that have transformed at higher temperatures that it seems improbable, given an adequate supply of useful alloy elements, that hardenability will ever have to be sacrificed to secure greater immunity from temper-brittleness.

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[1] J. H. Hollomon: "Temper Brittleness," "Trans." Amer. Soc. for Metals, Vol. 36, 1946, page 473.

[2] H. Jolivet and G. Vidal: "Value of the Impact Test for the Study of Temper-Brittleness," *Revue de Métallurgie*, Vol. 41, 1944, page 378.

[3] W. S. Pellini and B. R. Queneau: "Development of Temper-Brittleness in Alloy Steels," Amer. Soc. for Metals, 1946, Preprint No. 16.

[4] J. B. Cohen, A. Hurlich and M. Jacobson: "A Metallographic Etchant to Reveal Temper-Brittleness in Steel," Amer. Soc. for Metals, 1946, Preprint No. 17

[5] J. H. Hollomon, L. D. Jaffe, D. E. McCarthy and M. R. Norton: "The Effects of Microstructure on the Mechanical Properties of Steel," Amer. Soc. for Metals, 1946, Preprint No. 25.

[6] *Journal*, Iron and Steel Institute, Vol. 102, 1920, page 171.

[7] *Journal*, Iron and Steel Institute, Vol. 111, 1925, page 231.

[8] Second Report of the Alloy Steels Committee, Iron and Steel Institute, 1939, page 343.

Brittleness of Aluminium as it Cools from the Casting Temperature

Certain defects in aluminium castings, apparently due to brittleness at high temperatures during cooling, led H. Jolivet and M. Armand* to investigate the behaviour in a bend test of aluminium of three grades of purity as it cooled in the mould from the casting temperature. The tests were made on material of the following percentage composition:—

	Iron	Silicon	Aluminium
Sample A	tr.	tr.	99·99
„ B	0·17	0·31	99·52
„ C	0·46	0·35	99·19

The liquid metal at 800 deg. Cent. was cast into small rectangular ingot moulds preheated to 650 deg. Cent. Each mould was fitted with a lateral hinge, which allowed the specimen to be bent through an angle of 90 degrees at different temperatures during cooling.

It was found that the specimens cracked or broke on bending above a certain temperature, t_1. The brittleness disappeared progressively over a very narrow range of temperature, from t_1 to t_2, below which the specimens bent without cracking. For the compositions B and C this range of temperature, in which the brittleness disappeared, was 580 deg. to 570 deg. Cent. for rapid cooling (about 60 degrees per minute) and 630 deg. to 620 deg. Cent. for slow cooling (about 4 degrees per minute). When the specimens, cooled at the rapid rate, were reheated, they showed no brittleness below 620 deg. Cent.

This behaviour was explained by Jolivet and Armand on the evidence of micro-examination. Brittleness down to 620 deg. was associated with the presence of the fluid aluminium-iron ($Al\text{-}Al_3Fe$) eutectic; the lower temperature to which it persisted on rapid cooling was due to the fact that segregation of silicon gives rise to the formation of the aluminium-silicon-iron eutectic, the freezing point of which is as low as 575 deg. Cent. The disappearance of brittleness at this temperature on reheating is related to the diffusion and solution of silicon which then takes place.

The behaviour of the pure metal, which, presumably, according to this explanation, should be free from brittleness at all temperatures below the freezing point, was not described.

**Comptes Rendus*, 1946, Vol. 222, pages 946–948.

Aluminium versus Copper for Electrical Purposes

The comparatively long-standing competition between aluminium and copper for use as electric conductor cables for long-span high-voltage construction has of late years been accentuated by the more favourable price of aluminium in relation to copper and by the increased need for long spans. Experience with aluminium-cored cables in many localities is surveyed in *Light Metals*, December, 1946; and in *Materials and Methods*, February, 1947, H. A. Knight shows how strong a contender aluminium now is, especially in America, for many electrical applications. The use of steel-reinforced aluminium cable has made even longer spans practicable. As an emergency measure, electric motors were wound with aluminium in place of copper and for one war application 15,000 aluminium-wound motors were ordered. If frames designed for copper are used, the horsepower ratings of such motors are naturally much lower on account of the lower conductivity of aluminium. The use of hard-drawn aluminium wire for electrical purposes in buildings has also increased enormously, many of the earlier difficulties in making soldered joints, &c., having been overcome. For equal conductivity, aluminium is, of course, more bulky than copper. It seems, therefore, that for underground cables, where compactness of electrical conductivity is necessary, copper has no equal commercially. The general conclusion to be derived from the article here quoted seems to be that for bulk items, aluminium will ultimately come into general use, while copper will continue to be employed for the more compact, smaller or more precise mechanisms and equipment.

THE ENGINEER

APRIL 4, 1947

VOL. CLXXXIII No. 4758

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NOTICE TO READERS

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F.B.I. AND T.U.C. STATEMENTS

THE respective statements issued in the last few days by the Federation of British Industries and the Trades Union Congress are considerably more inspiring than the Government's "Economic Survey for 1947," upon which they are designed to comment. Indeed, as will be seen from the short extracts we reprint on another page from the former document, the Federation has some very definite and realistic proposals to put forward to meet the economic situation in which this country finds itself. If the T.U.C. document, summarised in our "Industrial and Labour Notes," seems less inspiring, the reason probably lies in the fact that the General Council has decided "at this stage" not to publish the report of the committee which has been considering "measures to deal with both the immediate emergency and the general problems presented by the White Paper," though it expects that "the recommendations adopted . . . will be the subject of discussion with the Government."

Since the full details of the T.U.C. proposals remain unknown, it is not possible to make a complete comparison of the views of the two bodies. Yet there is enough in the T.U.C. statement to show that in many respects there is an encouraging measure of agreement with the F.B.I. upon the actions that ought to be taken. Both bodies, for instance, consider that the target of 200 million tons of coal in 1947, as proposed in the White Paper, is too low. Each recommends a target of 220 million tons, although that output refers to the calendar year in the T.U.C. document and is applicable to the coal year in the F.B.I. statement. The view expressed in this journal in commenting on the White Paper that an output of 200 million tons was not sufficient to support the planned industrial output, thus receives reinforcement from both sides of industry. The T.U.C. statement indicates that suggestions "as to special measures to improve the production of coal and to assist in attracting labour to the industry" have already been sent to the Minister of Labour. The further remark of the T.U.C. Council that the continuation of the present arrangements for spreading the electricity load cannot reasonably be contemplated for "as long as two or three years" will undoubtedly attract sympathetic agreement from the managerial side. It is re-echoed in the F.B.I. document in the statement that the idea that it must now take three or four years to build large new power stations should not be accepted and that "resources for building power stations and manufacturing their equipment should be mobilised, guaranteed their necessary supplies, and set a programme based upon a two-year construction interval." Both documents, too, draw attention to the need to increase internal transport capacity. In general, however, the F.B.I. proposals are the more definite. Whereas the T.U.C. remarks that "the great need is to re-establish a stable balance between all our essential industries and to get them running in step, so as to avoid any further disruption," the F.B.I. makes the observation, more enlightened to the reality and urgency of the problem, that "the Government should ensure that activities which are adjudged essential as short term objectives shall be fully—and continuously—supplied with their needs in fuel and materials, while other activities or projects, whether productive or non-productive, are cut back." It is, indeed, surprising that such a remark at this late date should continue to seem forceful. For over eighteen months Government spokesmen have been speaking of a planned economy. But, in fact, the White Paper and even more sharply the fuel crisis throw into relief the inadequacy of what plans there are. Controls, indeed, exist. "But," to quote the F.B.I. statement, "the idea that a central plan can be enforced by a host of detailed controls is false. . . A technique must be developed by which the responsibility for carrying the broad plan into effect is diffused through industry."

The F.B.I. statement makes no reference to labour questions, whereas the T.U.C. document does; and it is these references that we find particularly disappointing. For the T.U.C. Council finds the White Paper statement that "the nation cannot afford shorter hours of work unless they can be shown to increase output per man-year" ambiguous and considers that it sets "an impossible standard by which claims for, for instance, a shorter working week can be judged." It is difficult to see where the ambiguity lies and why such a standard should be regarded as impossible. For the fundamental justification for a shortened working week must always lie in the possibility over a term of years of so much increasing output per man-year that productivity and, in consequence, the standard of living remain unaffected by shortened hours of work. Indeed, it might well be claimed, were the times normal, that productivity has so much increased per man-year since the 48-hour week first became widespread that the time is now due for a general reduction. But the times are not normal. The need to produce is so urgent if the nation is to recover even that standard of living that it experienced before the war that it is, surely, literally true that "the nation cannot afford shorter hours of work unless they can be shown to increase output per man-year." The T.U.C. statement goes on to complain that it would be "unfair and impossible to expect workpeople in industries still working a 48-hour week to abandon their claim to an improvement which was already well advanced when the White Paper was published." Has the fuel crisis, emphasising so vividly the reality of our economic circumstances, and has the publication of the White Paper, revealing in more detail the real position, made no difference, then, to our appreciation of our present situation? Are we to understand that the T.U.C. does not recognise that an improvement in knowledge about the real circumstances may require also modification or postponement of a plan drawn up before that knowledge became available? Unless it can be shown that output will be improved thereby, can the nation now afford to grant a reduction of working hours in the industries concerned? There is much sympathy for the desire of the workers for shorter hours. It is admitted that sooner or later shorter working hours must be applied generally. But is a period of low-living standards, a period of shortage, and a period when inflation threatens, if output cannot be improved, a propitious time at which to ask for them? We wonder whether the sharp taste of temporary unemployment widespread over the country as a consequence of the fuel crisis may not have brought home to the men in the shops better than to their leaders in the T.U.C. the realities of the nation's economic circumstances.

FLYING AND THE COMPRESSIBILITY STALL

EVEN if history does not really repeat itself, some types of emergency certainly seem to do so. We are, we are told, about to be challenged by a new type of aircraft "stall," one which will call for the fullest skill of our pilots and, so far as they can help, the highest ingenuity and resourcefulness of our designers. Many readers will be old enough to recall that seemingly mysterious phenomenon, the "spin," which led to so many accidents the best part of a generation ago; its cause was only gradually discovered. It was found that by some mischance the flying speed became too low, the craft stalled and thereupon fell into the right or left-handed spiral, which, as it happens, is one of the forms of stable motion which flight can assume. From this risky path some technique had to be discovered to enable the pilot to regain normal control before the ground

was hit. Thanks to close thinking by aerodynamicists and very gallant experimental flying by test pilots and others, the right technique was found, and it soon appeared that, given sufficient altitude, there was little danger in this form of stall and the resulting spin.

The new threat comes at the other end of the speed range and its sudden advent arises from the amazing rapidity with which the thrust given by the new jet turbines has been increased. Although the speed of sound at sea level is as high as 750 m.p.h., it sinks to 650 m.p.h. in the stratosphere, and it is when this range of speed is approached at any height of flight that there comes a sudden break in the air flow just as drastic as that in the low-speed stall and fully as sudden in its onset. Warnings of the new stall come at values of the Mach number of 0·8 or 0·9, depending in a way not easy to estimate in advance on wing and fuselage shape. When the Mach number reaches its critical value the drag rises enormously and the centre of pressure of the air forces changes position rapidly and with it the flying trim. These effects can be studied and to some extent forecast from wind tunnel experimentation, but it is not easy to obtain quantitative data from flights in free air. Such flying can be exceedingly dangerous, and it is not for nothing that steps are being taken on both sides of the Atlantic as well as in Australia for some of this investigatory work to be carried out on pilotless aircraft under radio control, and with radar recording. Nevertheless, there have been many instances of test pilots who have, with immense courage, taken their lives in their hands to carry out flying tests at these speeds, seeking the danger and essaying its control. One of these was the late Mr. de Havilland; had he survived we should no doubt be the wiser for what in his last flight he was discovering in this little-known realm.

Not all test pilots have the gift of telling what they have learnt in words which can be a useful guide for others, and we welcome the recent publication of a statement of the present position as seen from such a pilot's point of view. The writer, Wing-Commander Beaumont, a demonstration pilot of Service aircraft at the de Havilland works, tells us that even when the 400 m.p.h. fighter arrived there came a foretaste of trouble by loss of control when diving. This took the form of a degree of fore-and-aft pitching which the elevator could not control; indeed, normal flying was not regained until, by loss of altitude and consequent rising air temperature, the Mach number became less than the critical value. In his view pilots must expect that with the coming of the 600 m.p.h. jet fighters they will often encounter compressibility effects not only when diving, but in level flight, and they must prepare themselves accordingly—not by seeking to avoid ever entering that *régime*, which they would not be able to do in any case, but by knowing what to do when they find themselves there. Though, while recovery from a low-speed stall in a contemporary fighter may, as the Wing-Commander points out, be completed in a few thousand feet, recovery from the compressibility stall may take as much as 10,000ft. It is instructive to know that from the pilot's point of view the leading characteristics of this new form of stall are a sudden change of trim accompanied by a growing lack of stability, coupled in some cases with a severe form of airframe vibration. Such are the warning signs. It is fortunate that it is in the lower regions of the atmosphere that the danger is least to be feared; these warmer levels act indeed as a useful cushion when nearing the earth's surface. This useful effect will be the more welcome if attempts, of which we read in the Press, are made to force piloted aircraft right through the compressibility "barrier" into the supersonic speed regions beyond. We shall watch any such brave efforts with sympathetic interest but, we confess, with some anxiety.

The Institution of Mechanical Engineers

AT the Annual General Meeting of the Institution of Mechanical Engineers, last Friday, March, 28th, the President, Mr. O. V. S. Bulleid, as soon as the minutes had been read, presented the Annual Report of the Council to the meeting. Some short abstracts from that Report follow.

Annual Report

The growth of membership during the year has continued at a high rate in spite of the increasingly high standards demanded of candidates, and it is a matter of gratification that the number of entrants in the Graduate and Student classes has been so well maintained.

Although most of the wartime restrictions on the use of paper for printing have continued during 1946, it has been possible, through the device of the War Emergency Proceedings, to make available to members some 60 per cent more material than appeared in 1939, during which year the largest volume of Proceedings was published.

Two conferences were held during the year: on 20th, 21st, and 22nd February, a series of nine lectures on the Development of the Internal Combustion Turbine were delivered; and on May 24th a whole-day conference was held for the discussion of fourteen papers on different aspects of machinability. The attendance at the former was such as to necessitate the holding of a second series of meetings a month later.

The Conference of Commonwealth Engineering Institutions, held in September on the invitation of this Institution with the Institution of Civil Engineers and the Institution of Electrical Engineers, marked an important step in the evolution of Engineering Institutions in the British Commonwealth, and all those who participated have paid tribute to the value of the discussions.

In connection with the proposed amalgamation with the Institution of Automobile Engineers, a poll of all Corporate Members was taken on the three motions concerned with the proposals. On the resolution to amalgamate the voting was 3548 for and 1684 against; on the resolution to add to the Royal Charter to permit of amalgamation the voting was 3536 for and 1680 against; and on the resolution to make additions to, and amendments in, the By-laws, necessitated by amalgamation, the voting was 3534 for the resolution, and 1681 against. The polling papers were returnable on or before February 12th. The necessary petition was submitted to the Privy Council and the year ended before the decision had been communicated to the Institution.

Inventions and Research

High-Duty Cast Irons for General Engineering Purposes.—The work carried out for the Institution at the British Cast Iron Research Association's establishment at Alvechurch has been completed, and will form the subject of the Committee's Fourth Report, which has been approved and which will deal largely with the results of the investigation of the properties of acicular (needle-shaped crystal structure) cast irons, including the effect of different alloying elements and impurities. A monograph on the properties of cast iron in relation to design is also in course of compilation.

The Chairman of the Committee has been Professor A. L. Mellanby, D.Sc., LL.D., Hon. M.I.Mech.E., and the work has been conducted at the British Cast Iron Research Association under the supervision of the Reporter, Mr. J. G. Pearce, M.Sc., M.I. Mech.E.

Pipe Flanges Research Committee.—Some experimental work has been resumed by the Committee in connection with their Third and Final Report, completion and publication of which was interrupted by the war. The Second Report was published in 1939 and it was intended to publish the Third Report in the ensuing year.

Joint Standing Committee on Research of the Institution of Mechanical Engineers and the Institution of Production Engineers.—No meeting of the Joint Committee has been held during the year. At the last meeting in 1945, Parts III and IV of the Acceptance Test Charts for Machine Tools were approved for publication but have not yet been issued.

Researches in University Laboratories.—Grants in aid of research of private workers in university laboratories were made from the Institution's own funds, or from funds at its disposal, as follows:—

(*a*) *Battersea Polytechnic.*—For an investigation into the hydraulic ram.

(*b*) *College of Technology, Manchester.*—For work on the design and action of screw-taps and for an investigation into the component forces acting on the point of a lathe tool by means of a cutting tool dynamometer involving the use of strain gauges.

(*c*) *King's College, London.*—For the construction of a differential analyser.

A donation from the James Clayton Fund was made towards the cost of researches into the early stages of metallurgy undertaken by the Royal Anthropological Institute.

Mr. J. F. Petree then made some criticisms of the Report. But that was not, he said, his main object. He felt that there might be a number of such points on which members might desire to comment or to ask questions. Moreover, the present meeting was an open one at which visitors were present and there might be matters which members would like to discuss which it would be preferable not to discuss in the presence of non-members. It would cause much inconvenience to ask non-members to withdraw. He therefore proposed "that the consideration of the Report and Accounts for 1946 be deferred to a subsequent meeting at which there will be no visitors present." This proposal was seconded and after

a lengthy discussion a vote was taken by show of hands. The proposal was carried. No date had been fixed for the deferred meeting at the time of going to press.

The presentation of prizes for papers read in the previous session followed, and the President then called upon Mr. C. H. Woodfield, a member of the Committee of Management, to make an appeal on behalf of the Benevolent Fund of the Institution.

The result of the ballot for election to the Council was announced by the secretary as follows: President, Lord Dudley Gordon; Vice-Presidents, Dr. Dorey and Dr. Pye; Members of Council, Mr. T. A. Crowe, Mr. F. W. Hawksworth, Major-General E. Bertram Rowcroft, Dr. S. Livingstone-Smith, Mr. Desmond Carter, Mr. C. K. F. Hague, and Mr. H. G. Conway.

A vote of thanks to the retiring President having been proposed by Dr. Lee and seconded by Sir William Stanier, Mr. Bulleid inducted Lord Dudley Gordon into the Presidential Chair.

Papers entitled "The Norwich Heat Pump," by J. A. Sumner, and "The Air Cycle Heat Pump," by T. F. Thomas, were presented. Unfortunately, owing to the lengthy debate that had taken place on the Annual Report, the discussion of these papers had to be cut very short.

Obituary

HENRY MARK PEASE

TELEPHONE and telegraph engineers in Great Britain and America will have learned with regret of the death in New York Hospital, on Friday, March 7th, at the age of 71, of Mr. Henry Mark Pease. He was Vice-President and director of the International Telephone and Telegraph Corporation, and Vice-Chairman and director of the International Standard Electric Corporation, its associated manufacturing company. In addition, Mr. Pease was Vice-President and director of the Federal Telephone and Radio Corporation and a director of International Telecommunication Laboratories, Inc. He was born at Malta, Illinois, in 1875, and graduated as B.Sc. from the University of Illinois in 1898. Mr. Pease joined the Western Electric Company in Chicago after leaving the university, and in December, 1902, he was transferred to the London branch of the Western Electric Company to supervise the installation of central battery telephone exchanges for the G.P.O. and the National Telephone Company. He was first appointed to the telephone engineering department of the firm, and in 1907 was transferred to the sales department. In 1909 he became sales manager, and four years later assistant manager, and in 1919 he was appointed managing director of the Western Electric Company, Ltd., in England. About 1922 he took an active part in the formation of the British Broadcasting Company, and was one of its original directors. His firm supplied the transmitter for the Birmingham station, and the following year Mr. Pease negotiated the contract for the first transatlantic radio telephone transmitting station with the British Post Office, and his London company began the manufacture of that apparatus. In 1925, when the International Western Electric Company changed its name to the International Standard Electric Corporation, Mr. Pease became the managing director of Standard Telephones and Cables, Ltd., the British company. In 1927 he was made general manager of all the Corporation's undertakings in Europe, Africa, Australasia, and India, and he returned to New York in 1933.

ANDREW MILLER ALEXANDER

FEW Civil engineers in recent years have had a longer, more varied, and successful career than the late Mr. Andrew Miller Alexander, whose death—recorded in THE ENGINEER last week—took place suddenly at his home in Trimingham, Norfolk, on Saturday, March 22nd. He was 92 years of age and although he had retired from active service he continued to attend the London board meetings of Creed and Co., Ltd., of Croydon, of which he was deputy chairman, up to December last. He was educated at the Glasgow Academy and continued his studies in Switzerland. In 1872 he began to serve a five-years' apprenticeship with Barclay Curle and Co., Ltd. On completing this training he joined the Caledonian Railway Company under Mr. George Graham, M.Inst.C.E., who was then its engineer, and was engaged on several Scottish railway schemes then under construction. In 1881 Mr. Alexander left this country to take up a position as engineer with the Australian Railways in Melbourne, and the year following he accepted a position with the Melbourne Harbour Trust as assistant engineer. Later he became acting chief engineer and engineer-in-chief. He had full charge of all floating plant and new construction, and was on the commission appointed for the repair of H.M.S. "Nelson." On his return to Great Britain, Mr. Alexander was for some time the city engineer of Belfast. In 1898 he joined the Thames Ironworks and Shipbuilding Company, Ltd., and was given head charge of the company's civil engineering work. In that capacity he had to do with, among other schemes, the Damascus Railway and the projected Cape-to-Cairo Line. He was also responsible for the building of no less than sixteen large caissons for Admiralty and mercantile docks at Keyham, Swansea, Hong Kong, Singapore and Gibraltar. In 1902 he was made a director of the firm, and in 1906 he became deputy chairman, with charge of all departments. On retiring from the firm he set up as a consulting engineer. He then joined the firm of Creed and Co., Ltd., of Croydon, the makers of teleprinters, which during the war was responsible for the making of very high precision apparatus for the fighting forces. Later he was appointed deputy chairman of that company. He was a member of the Institution of Civil Engineers and the Institution of Naval Architects.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EMPLOYMENT OF "OVER-FORTIES"

SIR,—Having read with considerable interest your two articles in this week's issue on the activities of the Professional Engineers' Bureau and the position regarding the "over-forties" I feel prompted to write you for publication in your columns, if you so desire, to enquire of the employers generally what they have against employing good brains, well matured in the complexities of technical, practical and administrative work, still active enough to do good work, as evidenced by those holding good positions at over forty years of age; but once such positions become void through redundancy or other reasons, these same men are shelved because they are, according to the standards set to-day, "over-age"!

What is to become of these qualified engineers? A short while ago one of the evening newspapers was decrying the shortage of skilled labour. Is there a shortage? Or is it the age bar that presents a fictitious shortage? These engineers, it will be generally found, have given loyal service to the profession and the employer, probably over a great number of years in one office, and then find themselves jobless owing to changes in policy or post-war redundancy; for this position why penalise them? At one time humans were regarded as in the prime of life in the fifties. Is the country to lose this potential executive power on account of age-bar fad-dishness?

I am, of course, in this group. Hence this letter, which is written not for self-advertisement, but rather for the purpose of endeavouring to wake up our employers, for them to broaden their views when advertising for "humans," and so I shall sign this letter with a *nom-de-plume*.

There is another bar to job-getting these days applying to all age groups. It is that of "pedigree." If one has not had long and previous experience in the particular class of work covered by the advertisement specification the likelihood of getting the post is remote. American employers usually take an applicant at face value and if proved in the job undertaken it is held, otherwise—out. It is time our captains of industry did likewise, as a properly trained man in his profession can apply, and successfully, fundamentals to the various classes of work within the industry, even if he has not seen the light of a similar job before.

"ANXIOUS TO SERVE."

Kent, March 29, 1947.

THE GREAT FROST

SIR,—Your correspondent "Bell" hypnotised by that attractive expression, "a planned economy," does not stop to inquire whether there is at the moment any national plan. The announcement that an expert planning staff is about to come into existence would indicate that the plan is still in the womb of time.

It is known that great industries like the steel trade and both municipal and company-owned electric supply stations have had their development plans put into cold storage for the last two years, whilst the Board of Trade pushes into the export drive the new plant they require. The basis for the export drive is the necessity to import food; but it is also known that home production of food could be enormously increased if it were given the priority due under a national plan worthy of the name. For increased production in all industries, what is wanted is neither scolding nor sentimental appeals; but, as your correspondent admits in his final paragraph, "incentive"; in other words, giving the individual something to work for.

So long as this essential is derided under the title "profit motive," so long, I fear, will the planned economy be a great frost.

F. L. WATSON.

Lyndhurst, March 24th.

BOOKS RECEIVED

Chemicals from Methane. By J. P. Lawrie. London: Science Services, Ltd., 255, Russell Court, W.C.1. Price 3s.

Dictionary of Plastics. By Paul I. Smith. London: Hutchinson's Company, Ltd., 47, Princes Gate, S.W.7. Price 15s.

Electric Filters. By T. H. Turney. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 25s.

The Institution of Naval Architects

No. II—*(Continued from page 269, March 28th)*

FOLLOWING the Presidential Address on Wednesday, March 26th, a paper by J. E. Church on "Improved Arrangement of Accommodation for Modern Cargo Vessels" was presented.

Discussion

Mr. T. R. Lees remarked that it was perhaps unfortunate that the paper had been limited to accommodation in ocean-going cargo vessels because that was the easiest type of vessel in which to make reasonable improvements in the crew accommodation. In the case of the large passenger liner or mixed passenger and cargo liner, concerning which there were a number of Board of Trade standards at present, the problem was quite a different one.

Sir Wilfred Ayre agreed that the outline of accommodation given by the author might be regarded as a normal development of the present age, and he would not say it would not go farther. No doubt it would, but it brought to mind the fact that shipowners were being accused of building ships at too high a cost. If we cast our minds back and compared the 9000-ton vessel of ten years ago with what was contemplated now, improved accomodation for the master and officers and crew, increased speed, increased efficiency of the propelling machinery, &c., it was not difficult to assume that all these things would account for an increase in cost amounting to 40 or 50 per cent.

Mr. E. W. Blocksidge said that the general question of crew accommodation had been discussed at many international conferences of shipbuilders and it had been decided there were great drawbacks to the accommodation at present provided in the foc'sle. Various Governments had done their best to give encouragement to shipowners to provide better accommodation for the crews, especially the British Government but, in spite of that—and he said this very carefully, as he had had experience in an official capacity in working out crew space regulations in pre-war days—there had been a certain amount of frustration both from the shipowners and shipbuilders in working in line with the Government recommendations. Nevertheless, it was all to the advantage of the shipowners to provide improved accommodation for the crew and he hoped the time was not far distant when the shipowners of all countries would come into line so that they could all work to the same regulations.

Mr. Church replied shortly.

The next paper presented was: "British Submarine Design During the War," by A. J. Sims.

Discussion

Sir Stanley Goodall said that the military gains from welding were more in the case of submarines than in any other class of warship, but, of course, it was very necessary, before making such a change in practice, to be quite sure that it could be made without disasters. In the first place, it had been necessary to find a more weldable steel for the pressure hull than was in use when riveting was practised. A great deal of preliminary work was necessary; there was the importance of accurate circularity, and close investigation into the problems of design in the way of openings and discontinuities was necessary because local weakness in a welded submarine might prejudice the whole scheme and the result would be disastrous. It was now known that weaknesses of that nature did occur in some of the German designs. A great deal had been heard about German designs until the "Graf," as we called her, was captured almost intact in 1941, and after that we heard less about the vast superiority of German submarines. Samples of the steel from the pressure hull were taken, tested and analysed. There was nothing peculiar about the steel of which the German submarines were made. In fact, it was rather dirty. The production of submarines, their machinery and their equipment was essentially a matter for the specialists, and in that respect a heavy blow was dealt at production in 1939 when the "Thetis" was lost. He himself lost two of the most valuable members of his staff and Messrs. Cammell, Laird's submarine specialist team was sadly depleted. Submarines never had the highest priority except for one short period when the "A" class was under construction. Unlike Germany, where the major call was for submarine construction, we had a very big merchant shipping programme and a vast programme of repairs. Further, there was a multiplicity of warships of all types being built and submarines generally had rather a poor place.

Mr. R. Baker, speaking on behalf of Sir Charles Lillicrap, remarked that valuable and welcome as Mr. Sims' paper was, he felt very strongly that it would be improved very considerably if there were added comparable figures and particulars of contemporary German submarines, or perhaps Mr. Sims could write a comparison paper on them. Shortage of suitable building capacity meant that for a large part of the war, design and methods of construction were frozen so that it was not until near the end of the period that we were able to follow the Germans and Americans and produce all-welded types. Future ships and submarines which were not practically all-welded, would carry too heavy a load to compete with the more modern structures.

Engineer Rear-Admiral Frew said that the introduction of air-conditioning vastly improved the humidity and operational conditions in submarines, with the result that at the end of a patrol extending, as it often did in the Pacific—where the temperatures were high—up to fifty days, the crews were fresh and ready to go out again. Another problem was noise of machinery, and the biggest headache in this connection during the war was the singing propeller, particularly under submerged conditions.

Capt. Lord Ashbourne dealt with some of the criticisms that had been made of our submarine design during and since the war, compared with German and American submarines. Ours had been criticised as having an inferior speed on the surface and also less maximum diving depth. There was, of course, substantial foundation for those criticisms, but it must be borne in mind that the Germans and Americans did not get their extra surface speed and greater diving depth without giving up something. The Germans had to give up battery capacity and the Americans had to go to what we regarded as large submarines, and we, on our side, were unwilling to accept those limitations. The German submarine was designed primarily to operate in the broad spaces of the Atlantic and therefore had to have high surface speed in order to intercept our convoys. It was also necessary for the German submarines to have great diving depth in order to escape from our very effective anti-submarine measures. The American submarines, it would be true to say, were primarily designed for operating in the Pacific, where size was not a matter of particular importance. As far as habitability was concerned, it was an advantage, quite apart from the practical advantage of high surface speed. The American submarines had enormous distances to cover from their bases to their patrol areas, which medium-speed submarines would have taken a disproportionate time to carry out. On the other hand, our submarines were designed for world-wide operation and they did, in fact, operate from the Arctic to the Equator. Their principal duty, of course, was offensive patrol, and for that purpose they had to operate for weeks or months on end completely unsupported and frequently, if not usually, close to the enemy's coast. For that purpose large battery capacity and long diving time was absolutely essential, and he did not believe there had ever been any complaint by submarine commanders that they had too much battery capacity.

Commander Cowell, speaking on behalf of the Flag Officer, Submarines, said that from the submariner's point of view we should never have enough submarines and, due to production difficulties and the changing theatres of war, those which could be produced might not be of the most suitable type. It might be that for the future we should have to change our concept of the "all-purpose" submarine, but any design must take into full consideration the need to step up production in wartime.

Mr. F. O. John said the paper reminded him of the very strenuous times they had at Cammell, Laird's in the endeavour to build submarines in the minimum time. For welding work there was one welding supervisor to every ten welders, and every run was examined before the next was proceeded with. Several of the hulls were tested to an internal air pressure of 150 lb. That in itself was something of an innovation, but everything went very well and the men were impressed with the fact that only the very best welds would be accepted.

Engineer G. de Rooij (Director, Naval Construction, Royal Netherlands Navy), commenting on the statement in the paper that "automatic welding was employed as far as possible," asked which parts of the hull were so welded and which system of automatic welding was used. Dutch submarines, built after 1935, were constructed from high tensile steel, electrically welded for the most part. Some gangways of the pressure hull were of armoured steel, also electrically welded. Was high tensile or armoured steel used for British submarines, and were these parts of the structure also electrically welded? Could Mr. Sims say what kind of welding joint was used for the butts and seams: overlapped joints or V-joints? Also, were the latter with or without an underlaid strip? Again, were the roots of the V-joints chopped out and welded again? On Dutch submarines they had used, with great success, hydraulically-operated rudders, periscopes, anchors and Oerlikons. Had there been experience of this in the British Navy?

Mr. Sims replied shortly.

(To be continued)

Recent Developments in Calculating Machines

MEMBERS of the Measurements Section of the Institution of Electrical Engineers welcomed Professor D. R. Hartree, M.A., Ph.D., M.Sc., F.R.S., M.I.E.E., to their meeting in London on March 7, 1947, when recent developments in calculating machines were discussed.

Professor Hartree opened the discussion and prefaced his remarks by referring to the two classes of calculating equipment which can be used for performing numerical calculations. One class consists of devices operating on the principle of representing numbers by physical quantities of which the numbers are the measures; these measures operate with the quantities and finally measure a physical quantity to produce the answer. For example, multiplication of x by y can be achieved by passing a current of x *mA* through a resistance of y ohms, and measuring the p.d. across the resistance in millivolts. In this class are the slide rule, planimeter, the Mallock machine for simultaneous algebraic equations, the differential analyser and cinema integraph.

The second class of equipment consists of devices which handle numbers directly in their digital form, usually, but not necessarily, by counting discrete events of some kind. Examples of this class are the ordinary desk calculating machines, such as the Brunsviga and Marchant, and the large Hollerith machines which use punched cards.

Devices of these two classes are termed "analogue" and "digital" machines, respectively, in the United States. There have been some recent developments in the field of the analogue machines: for example, the new differential analyser of Bush and Caldwell, and the instrument for evaluating non-steady heat flow by an electrical analogue developed independently by Beuken in Holland, Paschkis and Baker at Columbia University and Jackson at Sheffield. But the recent developments which are of greater interest because of present achievement and future promise, are in the field of the digital machines, and, particularly, large general-purpose machines designed to carry out automatically extended sequences of computing operations, which sequences can be changed from one calculation to another. Of these machines, the most interesting are the ones which use the technique of electronic circuits in order to provide a high speed of operation.

Functions of Components of a Digital Machine

In a digital machine it is not sufficient merely to have equipment for performing arithmetical operations; it is also necessary to have a storage or "memory" device, both for operating instructions and intermediate results, and this must be of such a form that numbers can be recorded into it and read from it in a time approximating to the time required for an arithmetical operation, which may be of the order of milliseconds in an electronic machine. A further requirement is that the machine must be capable of accepting information from the outside world regarding the calculation to be performed, and of supplying results to the outside world. There must also be means for mutual transfer of numbers between storage and the arithmetical input and output organs, if these are physically distinct. Finally there must be some form of control which can accept the operating instructions in sequence and ensure that appropriate action is taken.

Storage and control are aspects of an automatic machine at least as important as the means of carrying out arithmetical operations; the capacity of the storage and the flexibility of the control have a decisive influence on the scale and range of work which can be undertaken. The control should include a device capable of exercising some degree of judgement so that if the calculation reaches a point at which there are two or more courses of procedure open, the machine applies some criterion and selects the appropriate procedure on the basis of the result applying it.

The I.B.M. Automatic Sequence-Controlled Calculator

The general concept of a large general-purpose automatic calculating machine is due to Babbage (about 1838) and the I.B.M. automatic sequence-controlled calculator at Harvard is, in principle, very closely a realisation of Babbage's conception. It consists, not of a set of standard I.B.M. machines coupled together, but an assembly of I.B.M. components, some being components of standard machines and others designed specially for the purpose, built up and able to be connected so as to form a calculating machine of considerable power and versatility. It consists of a number (seventy-two) of mechanical counters, which can be connected with a continuously-driven shaft through magnetic clutches controlled by relays; the counters are fitted with electrical contacts through which an indication of the number registered by any counter can be obtained when required; a whole counter has one counting unit, with clutch and contacts, for each of its twenty-three decimal places.

The sequence of operating instructions is supplied to the machine in a coded form by holes punched in a paper tape. Tables of numerical information regarding functions required in the course of the work are supplied in a similar form; such interpolation between tabular entries as may be required is done by the machine.

Another group of calculating machines, developed particularly by the Bell Telephone Laboratories, uses electromagnetic relays for the computing elements, numbers being represented by configurations of groups of relays according to a specific code. Although numbers are handled in their digital form, these machines do not count, and addition is done by building an addition table into the interconnections between the relays. The first relay machine was a small one restricted to carrying out the single arithmetical operations of addition, subtraction, multiplication and division of complex numbers. Larger ones are under construction or have been completed recently.

The "ENIAC"

The only machine yet completed which makes use of the technique of electronic circuits is the ENIAC (Electronic Numerical Integrator and Calculator). This machine operates by counting electrical pulses, produced at a frequency of 100,000 per second, by means of an electrical counting circuit. It works in scale of ten, to ten-figure accuracy; it consists of a number of units for addition, multiplication, division, storage, control, &c., which can be interconnected by being plugged into sets of transmission lines. The sequence of operation is determined by these interconnections. Data can be fed in from punched cards, and the results are normally produced in the same form.

This machine was designed specifically for the step-by-step integration of the equations of external ballistics, but its organisation is flexible enough for it to be applied to many other types of calculation besides integration of differential equations.

Future Developments

The main advance to be expected in the near future is the development of a machine with greatly increased and rapidly accessible storage capacity. Examination of the kind of problems one would like to solve, given machines with the facilities and speed of ENIAC, suggests that a capacity of between 1000 and 5000 *numbers* (not digits) is desirable. Some method of storage quite different from those used in any existing machine will have to be used to provide the required capacity if one is to avoid using an excessive amount of equipment.

In the discussion which followed Professor Hartree's remarks, attention was mainly centred round methods of increasing storage capacity and speed of access to required results or operating instructions. Reference was made to the system of mercury vapour delay lines used in EDVAC (Electronic Discrete Variable Automatic Calculator) a new American digital machine about which information had just been released. Coded pulses with a basic element frequency of the order of a million per second were passed through the delay line, taken out, reshaped and put into circulation again until required. Not only did this greatly expand storage capacity, but any required number or instruction could be extracted in a time interval of the order of a millisecond, which was comparable with that required for any of the arithmetical processes, thus greatly increasing the overall speed of operation by comparison with ENIAC, in which punched cards had to be used for storage in excess of sixteen intermediate results.

Another system of storage based on the principle of the iconoscope was mentioned. In this a charged pattern, developed by photo-emission on one tube, is scanned, sharpened and impressed on another tube; then passed back to the first and so on until the information is required. Work so far carried out held promise that the performance of this system might rival that of the mercury delay line.

The problem of providing automatic indication of error arising from valve failure, dirt in contacts, &c., was one which had not yet been fully solved. One method, which had been used on the Bell Telephone Laboratories relay machines was to duplicate the equipment and cross check at each stage of the calculation; it was an extravagant method and there was scope for improvement. Any new system should take into account the importance of checking the validity of automatic instructions as well as the detection of arithmetical errors.

Several speakers commented on the remarkably rapid development of large-scale digital calculators in recent years. In Great Britain the ACE (Automatic Computing Engine) was now under construction for the N.P.L., and in America dozens of comparable plans were being actively pursued. It should not be thought that these new and powerful tools would displace the "humble computer," who was ready to solve most engineering and statistical problems with ordinary desk calculating machines. The challenge was rather to the mathematician who must adjust his scale of thought to the same degree as he would find necessary if a journey from London to Edinburgh in half a minute were accepted as a matter of course. Mathematical attacks on the problem of atomic structure, of aerodynamics at sonic speeds, and of equations of motion of air masses in weather forecasting need no longer be abandoned as being hopelessly unwieldy and lengthy.

Several speakers stressed the necessity of having staffs of mathematicians to advise on the capabilities of new machines, to check their proper functioning and, if necessary, to help with the interpretation of results. For this work the highest qualifications would be required and it was thought that only a central Mathematical Institute able to draw on the resources of a number of colleges and institutions would be capable of providing the necessary breadth of outlook.

Repair of Damaged Buildings.—The Building Research Station, of the Department of Scientific and Industrial Research, has recently issued Notes Nos. 23 and 24, two of a series on different aspects of the repair or restoration of war-damaged or neglected buildings. Note No. 23 deals with reinforced concrete beams damaged by explosion. The effects of explosion are usually local, with members shattered beyond repair in the immediate vicinity of the explosion, and relatively undamaged in an outer zone. Between the two zones lies an area within which repairs are necessary, and it is with the assessment of damage to and with the repair of concrete beams in that zone that the note deals. Note No. 24 deals in a similar way with reinforced concrete beams damaged by fire. Damage by fire is rarely local and careful assessment is required in order to decide whether to repair or reconstruct.

Radiocommunications and the Future*

By C. C. PATERSON, O.B.E., D.Sc., F.R.S.†

IN considering the whole range of subjects, to which our attention has been so well directed by the authors of the Convention papers, I thought it would be useful to classify the main lines of development. I should like to review the Proceedings of this Convention with the aid of this general guide and then, afterwards, we can reflect on what the future may hold.

Extension of Frequency Spectrum

Up to 1939 there had been only a few, though quite important, instances of the use of frequencies above 30 Mc/s. From the relatively small amount of experience with police equipment on these frequencies, it was apparent that they could be used to provide a substantially interference-free service of a high standard to aeroplanes in flight. The early recognition of the possibility of such a service, by those responsible for the communications of the Royal Air Force, deserves recognition, and we are glad to have heard Dr. Gates describe the early work which proved of such value in the Battle of Britain.

The Army was also quick off the mark at those frequencies with v.h.f. short-distance communication, using such equipment as the No. 19 Set, which was described by Messrs. Dalgleish and Hughes, and also the simple transceivers used between searchlight sites. However, owing to the semi-optical nature of propagation at these frequencies, their operational use appeared to be limited till later in the war, though the Americans made use of the lower frequencies in this range, where the optical properties are less pronounced.

Before the war, active work was in hand by the Admiralty and industry to find out how signals on centimetre and decimetre wavelengths could be utilised for communication purposes, and though this work did not lead to quite such an early extension in signalling technique as the use of very high frequencies, just mentioned, the work did ultimately lead to such an outstanding set as the No. 10.

Very briefly, then, we see that the higher frequencies were proven and found their sphere of application in wartime in a way that clearly points the way of future progress.

Modulation Methods

It must be evident to all who have attended this Convention, and the Radiolocation Convention also, that in our outlook upon modulation methods we cannot bury our heads in the sands of the past. Simple amplitude modulation is, admittedly, a great deal more complicated a problem than some 50-c/s or direct current engineering problems, but it is far from the last word in modulation technique. The mystic initials f.m. and p.t. have been heard many times at this convention, for both frequency and pulse-time modulation advanced greatly during wartime.

Frequency modulation was continuously studied by a very interesting, if almost unorthodox series of conferences between industry and the Services, and much useful information was interchanged. The use of frequency modulation was, however, limited, for by the time its advantages in the v.h.f. field became apparent our fighting forces were too deeply committed to amplitude-modulating equipment. The investigations carried out in this country on the use of low deviations showed the advantages of such systems, particularly in areas of high signal-noise ratio; as early as 1940 installations were in use which proved quite successful.

Here, then, we have the case where intelligence is conveyed, not by intentionally varying the magnitude of a sinusoidal carrier-wave transmitted through a communication channel, but by intentionally varying another time function of the carrier. New time functions are attracting more and more attention; our pulse-time modulation systems rely essentially on such functions, and the paper by Mr. Cook and others shows how far we advanced in a very short time.

We ought to recapitulate a little here. In the pre-war centimetre work referred to previously, the carrier was interrupted at audio frequency with equal "on" and "off" periods, and might be considered to have been the forerunner of the pulse technique. During the war similar apparatus was developed, working on about 9 cm, and the concept of time modulation was introduced; the carrier was now interrupted at supersonic frequency and the time duration of the "on" periods was varied in accordance with audio signals; thus the possibility of a telephony centimetre-beam transmitter appeared. The paper you have heard on the No 10 Set shows how the simple ideas evolved and how, by again introducing a new principle, it proved possible to interlace in time eight separate speech messages and provide a multiplex message. This was undoubtedly one of the major advances in communication technique during the war, and it will have a marked influence on future communication networks. All involved in that project deserve our warmest congratulations.

In passing, we should also note the supporting paper on carrier-shift keying which describes another major step forward. Again it is not the amplitude, but another function—the frequency—of the carrier that is changed in order to increase greatly the reliability of telegraphic signalling.

Propagation

A major step forward has been described by Messrs. Tremellin and Cox, who told us how, as a result of the work of the Inter-Services Ionosphere Bureau, it was found possible to put into the hands of a radio operator a series of charts which gave him the optimum high-frequency he should use in terms of the location of the transmitting and receiving stations, and the time of the day and the season. A large number of difficult theoretical problems have also been investigated which give us a better quantitative idea of the power required to provide any service. We have been told that the story is still incomplete, and how much more remains to be done, but the practical compromise schemes so far evolved look as if they would stand us in good stead until the last mysteries of the ionosphere are resolved.

It was at first considered that at wave-lengths below 10 m we were free of the vagaries of the atmosphere, but radar investigations soon showed us that we still had reflecting and refracting layers to deal with.

The sun, apparently, still controls our transmitting medium at the longer metre wave-lengths; rain affects the outlook on centimetres, and Nature has its own radio counter-measures in the selective oxygen absorption.

[Here the speaker briefly reviewed wartime developments in equipment design and in operational technique.]

Navigation Aids

It might be considered that the subject of navigation aids is outside the narrowest definition of the term radiocommunication. A broader interpretation may be permitted which gives us an opportunity to acknowledge the work of those still faithful to the older art of continuous waves whose efforts have tended to be overshadowed owing to the greater novelty of the radar technique. We have indeed to be grateful to those who, in a time of stress, brought to near perfection such aids as enabled our convoys at sea and in the air to maintain the transatlantic bridge.

While, in the main, the papers have dealt with the steps that have been taken to reduce still further the errors in bearings, it is with even greater interest that we note the development of the ray-selection technique, the simplifications in presentation and operation, and the potentialities of the wide-aperture systems.

Again, the Laws of Nature, and of the ionosphere in particular, govern the use to which such aids can be put and their particular place in the frequency spectrum, but the rival claims to places in the frequency spectrum of communication and of navigation aids have yet to be sorted out.

Perhaps the most interesting new technique in continuous waves is that for the determination of position by the phase of the carrier wave. I have mentioned before the growing importance of the time variable, as opposed to the amplitude variable, in communication technique, and I am sure we are to hear more of the systems that employ it.

Future Trends

We must now take a look to the future. Will the developments of the war period greatly affect our future progress in radiocommunication? In some fields we see swords already being beaten into ploughshares, but it is early to predict the verdict of history. In some areas progress has been enormously accelerated; in others it looks as if we are trying to make up for the way we have lost.

Civil Aviation

The relative advantages of the various aids to the pilot are gradually being sorted out. It appears probable that the differing facilities required over different parts of the world and the different economic factors involved will entail some differences in the long-range navigation aids adopted. While the nature of the aids is too detailed a question for us to examine here, it seems that in due time it will be possible to navigate at least any of the main short or long-distance routes by radio aids alone, and often with the radio aid controlling the automatic pilot and relieving the pilot of an appreciable amount of anxiety.

In landing and low flying the continuous-wave and radar aids will both be involved. Even in clear weather over an open sea the radio altimeter may be one of the best vital items of equipment, but in conditions of poor visibility also it is beginning to become possible to visualise the time when a passenger-carrying aircraft will be landed by purely radio aids. But that, of course, is not the whole problem. What are the expectations of giving such a service in practice with never a chance of a failure? That is a vital but difficult question which does not permit of experimental verification.

Civil Mobile Communication

If, by allocating a separate section to this class of equipment, I have, apparently over-stressed its importance, I would say in defence that it is a new class whose scope is yet to be explored. The good work done by the Police and Fire Services' radio equipment is well known, but in the v.h.f. range it will be only the rival claims on ether space which limit the further extension of radiocommunication to road, rail and sea transport. Quick information from and to a fishing fleet, the ability to redirect road transport, even calling up a patrolling taxi, the assistance that can be given in a marshalling yard or instructions to a breakdown gang on the railway—all these have financial value. In fact, one is tempted to list many other applications in which an extension of the Post Office line-network facilities to moving vehicles may prove to be a commonplace of the future. Such possibilities are

* Abstract. An Address reviewing the I.E.E. Radiocommunication Convention. March 28, 1947

† Research Laboratories of the General Electric Co., Ltd., Wembley, England.

largely due to the development of techniques in the metre and centimetre wavelengths.

Trunk Telephone System

The wartime developments will also have their repercussions on the communication network we nowadays take for granted and whose ramifications are lost behind the words "the telephone." During the war it became almost a commonplace to link islands to the mainland and to bridge rivers by a radio link; undoubtedly many obstacles of Nature will be overcome by such means. The longer links spanning oceans and continents will become more reliable because of our greater information about the ionosphere and our greater ability to overcome the defects caused by the ionospheric effects.

It is, however, when we pause to consider where the No. 10 Set will lead us that the most intriguing vista opens before use. So many economic factors are involved that I doubt if any responsible engineer is ready to venture the answer to the question, Will the beamed multi-channel centimetre radio chain replace the coaxial cable?

As far as communications in general are concerned, there can be little doubt that the Trunk Telephone System represents the backbone of the network. The efficient and economic operation of its vertebrae is made possible by the use of two elegant techniques, namely, the twelve-channel and the coaxial-cable multi-channel systems, the latter being capable of accommodating 600 channels on one tube. Here we have the meeting point of telephone and radio practice.

The high cost and comparative inflexibility of a buried-cable system would appear to be entirely justified as the primary trunk connection between the dense-population areas distributed along the length of a country such as Great Britain. However, in the secondary extension of such a network geographical difficulties such as wide river estuaries, or sea between an island and the mainland, are likely to arise. In these circumstances a radio-linkage system undoubtedly has attractions, and some installations are already in operation.

If a radio system is to function as an extension of an existing cable network, it is usually necessary that the extension should be capable of handling multi-channel carrier signals as presented by the cable. So far, frequency modulation has been found satisfactory for requirements up to twelve or twenty-four channels. The main problem in such cases is to approach a very linear modulation and demodulation so that cross-talk between channels can be avoided.

There are many places, such as in the larger islands, where a number of trunk channels can be collected together at audio frequencies, and it seems likely that a pulse-time modulation technique will be very suitable for such requirements. The audio signals are easily translated into suitable pulses, which are given their separate time allocations, while at the receiver the time-sorting of the mixed pulses naturally gives rise to an output at the separate audio frequencies. The problem here is to maintain each separate pulse waveform within the narrow time interval assigned to it. The appearance of multi-path radio signals will give rise to echo effects and hence to cross-talk. The engineer who can best control the behaviour of these echoes will undoubtedly produce the best operational system.

Both here and in America a direct challenge has been issued to the radio engineer to produce point-to-point radio systems of a quality and long-term stability at least as good as those normally associated with cable networks. Long radio chains are likely to have even more importance in the Dominions than in Great Britain. Radio systems have accepted the challenge of the cable, and it is reasonable to predict that we shall be near to the answer in the course of the next few years.

Broadcasting and Television

In reviewing the papers actually presented at the Convention, I did not refer to Mr. Bishop's paper on the "Wartime Activities of the Engineering Division of the B.B.C." It must have been clear, however, to all who have studied the paper that the B.B.C. has fully mastered the questions arising in connection with high-power broadcasting.

We have been told that the B.B.C. propose to develop v.h.f. frequency-modulation broadcasting. Such a project has the warm support of industry in that it should make available more clear channels wherein it will be possible to transmit high-quality broadcasting, covering the whole range of programme material desired by the public for entertainment and educational purposes.

We will turn to television in a minute, but first we should consider any implications of the developments in facsimile which, even if not exploited to the full, did, in fact, receive considerable stimulus during the war years. The questions raised are primarily commercial rather than technical. We need not do more than note that the technique is now available which would enable us to have a newspaper with up-to-the-last-minute news (if it is really wanted), reproduced in the home with a relatively simple radio receiver. According to the complexity of the equipment, such a receiver will reproduce either simple line drawings or high-quality photographs.

It is probably true to say that at the beginning of the war the rapid development of radar was very much facilitated by the availability of advanced techniques in cathode-ray tubes and circuits for television. Now the television engineer is anxious to apply his wartime experiences to the best advantage for television development.

The wise decision has been made that the B.B.C. should re-establish the 405-line service. This gives a chance to industry to design economic receivers on a realistic basis, and the next few years should see television established as a household word. But this is the *status quo*, and many will demand more tangible progress. The first reasonable step is to design and install a long-range linkage system which would enable broadcasting to be carried out on a national basis, programmes to be collected from the widest area, the cost of receivers to be reduced by quantity production, and a general improvement to be effected in B.B.C. income from licences.

Meanwhile, television developments abroad are being pursued with speed and determination, and this must be related to our long-term efforts. As far as domestic television is concerned, there is a real need for larger pictures, even, possibly, at some increase of cost. The problem of larger pictures is difficult enough of itself, and it is unlikely that a real solution will appear without the use of a picture signal of appreciably higher definition. The standard for higher definition is commonly assessed at between 800 and 1000 lines, with the former entirely adequate for domestic use and the latter high enough to meet most, if not all, of the requirements of large-screen cinema projection. Most of our techniques are ready for such development, although it need not be assumed that the cinema and the home must conform to the same television standards. At least we can say that our wartime experiences have made us familiar with much wider bandwidths, high radio powers at very short wavelengths, and high-gain aerial systems for broadcasting and for point-to-point linkage.

The fascinating problems of a colour system are slowly yielding to treatment, but there still seems to be a wide gap between scientific achievement and commercial possibilities.

Radio Interference

I shall now refer to radio interference only to remind us of a very important problem we still have to solve. The extension of electrification in this country and overseas demands that we consider two alternatives: either we can obviate the necessity for taking measures to reduce spurious radiation from electrical equipment, by providing high-power transmitters to overcome such radiation; or we can say that no spurious radiation must occur and use transmitters of much lower power.

A compromise appears essential. For example, mobile equipment cannot have unlimited power, and, alternatively, when high-power fixed stations modulate the ionised layers, mutual interference between signals occurs. The exact balance is one of economics, but there are the cases where safety of life is involved on the sea and in the air, and such services should be allowed special consideration. We may expect early attention to interference from our ignition systems, since the television service in particular suffers considerably from this source, and means of safeguarding car-ignition systems have been demonstrated on a large scale to be simple and practical. The v.h.f. services are all susceptible to such interference to a greater or lesser extent.

Export

Industry had, before the war, a fair measure of the requirements of the civil overseas markets but during the war the urgent needs of the fighting services hastened the development of materials and components to work under still more onerous conditions. We are therefore in a still better position to supply equipment engineered to the particular requirements of any specific locality, and, moreover, industry is well equipped to reproduce in its laboratories the conditions that have to be met overseas and hence to ensure a very high standard of reliability.

We shall see some changes in internal construction—primarily, perhaps, a replacement of the older materials with those less susceptible to the effects of fungus and humidity. In external construction and design there will be a move towards still further simplification. Our wartime equipment has pointed the way to future designs which will be suitable for installation and operation with little more instruction than that required for the ordinary telephone.

Throughout the war the world saw the research workers of this country taking the lead in most pioneer developments. We made the first moves in the metre and centimetre wavebands and disclosed the possibilities of a great extension of radiocommunication. This reputation must be maintained.

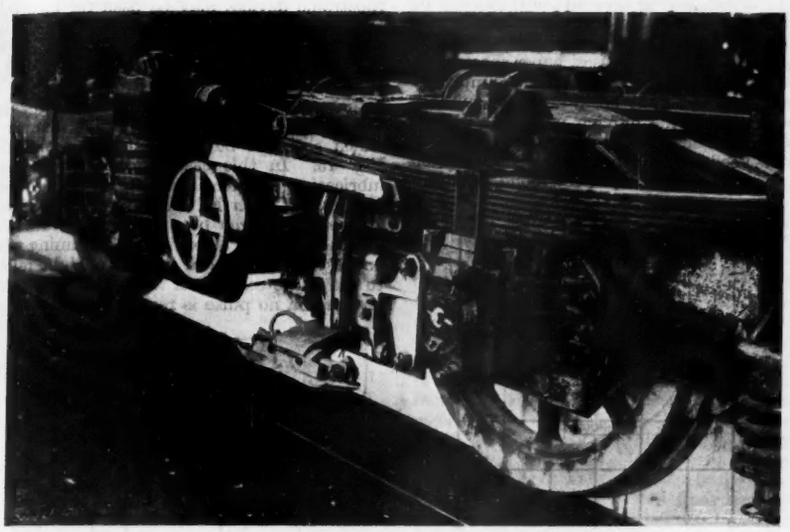
If I presumed, in closing, to give a message at this Convention, it would be that we must maintain the standard of our forward research workers in numbers and quality and our enterprise in quickly exploiting their work; our designers must follow closely on the heels of research and so ensure that we in this country really gather the fruits of their labours. Then we can go out in the confidence of our well-proved strength to take our due share in the markets of the world.

Shunting Locomotive Control in Canada

Canada's first successful two-way radio train order system installed in four of the Canadian "Pacific's" fifteen smokeless diesel-electric shunting engines at Toronto is a new step in improving fast freight services with the latest advances in railway equipment. Instantaneous two-way radio communication provided by frequency modulation short-wave equipment takes the place of a messenger, who, travelling on foot, was the only means a yardmaster had heretofore of keeping in contact with his crews in working hours. New orders for car movements coming in after a crew has left for a distant section of the yard are relayed immediately over the radio, thereby saving time by speeding up shunting movements. In all installations, pressure on a microphone button is all that is needed to operate a combination short-wave sending and receiving set. The main transmitting and receiving station connected to the two yard offices is set up in the Canadian Pacific Telegraph offices in downtown Toronto.

Retractable Collector-Shoe Gear

THE London Passenger Transport Board has made a number of experiments with shoe gear on railway rolling stock, and a new arrangement which has been introduced not only provides spring-borne shoe gear but also enables all shoes to be withdrawn from and held clear of the current rail by the operation of a hand wheel. The accompanying illustration shows the mechanism, as fitted to a car, with the shoe in the retracted position.



POSITIVE SHOE IN RETRACTED POSITION

Each shoe is carried on a rocking link, the pivot bracket of which is attached to the truck frame through insulation. The pins pivoting the shoe on the link and the link on its bracket are horizontal and parallel to the longitudinal axis of the truck. The shoes are thus free to rise and fall with their collecting faces always parallel to the collector rail. In order to lift the shoes clear of the current rail or to limit the fall of the shoe when there is no current rail under it, laminated balata straps are attached to the rocking links and a system of levers.

Above each positive shoe position is a horizontal beam pivoted on the bogie frame. One end of this beam rests on a stop on an axle box; the beam thus remains at the same height above the running rail, irrespective of the spring deflections. The balata strap supporting the shoe is attached to suitable points on the beam and rocking links, and maintains the shoe in the correct position relative to the running rail, independent of the truck frame height.

Hand wheels, connected together by a shaft carried in bearings on the truck frame, are provided on each side of the bogie, and to this cross shaft are attached cams which engage with the beams. With the shoes in the "down" position, the cams are clear of the beams, but their rotation through 270 deg. raises the beams clear of the axle box stops, at the same time lifting the shoes clear of the current rails.

The balata strap on the negative shoe rocking link is attached to a crank on a hollow shaft, which embraces the hand wheel cross shaft. This hollow shaft is rotated, through a link and a crank, by upward movement of either beam. The minimum negative shoe height above running rail level is controlled by the higher of the two beams and is raised clear of the conductor rail when the beams are raised by the rotation of the cams.

To avoid excessive forces being applied to the hollow shaft or on the beams with unequal spring deflection on the two sides of the bogie, some lost motion is incorporated in the linkage between the beams and the shaft. It will be appreciated that whilst a shoe is on a current rail the balata straps are loose and carrying no part of the shoe or rocking link weight. Adjustment is provided on the anchor points of the straps to accommodate variations in strap lengths and wear on shoes. Provision is also made for adjusting the height of the support points on the axle boxes to allow for different wheel diameters.

Both the retractable spring-borne shoe gear and a new form of fluorescent lighting are being tried out as possible prototypes for the 143 new cars now under construction, and for eighty-two cars to be modified to run with them, on London Transport's District and Metropolitan Lines.

British Resistance Welding Machine Manufacturers

AT the annual general meeting of the British Resistance Welding Machine Manufacturers, one of the B.E.A.M.A. sections, which was held in London recently, the retiring Chairman, Mr. J. M. Sinclair, of A.I. Electric Welding Machines, Ltd., said that the industry could be proud of the part it had played in the first post-war year. During the war welding had played an important part in the Pluto pipe scheme, the production of Jerricans, and the construction of aircraft and the making of munitions. With the engineering experience thus gained, resistance welding was of major importance as a production method in the motor-car, aircraft, refrigeration, electric cooker, housing and heating industries. It also played its part in the sheet metal, railway, shipbuilding and heavy steel industries. Through its association, the manufacturers had organised a technical committee, which had produced a system of rating resistance welding machines. This rating scheme was now accepted as a standard in the industry. The Committee had also prepared a booklet on the requirements of resistance welding machines as regards electricity supply. Mr. R. W. Ayers, of Sciaky Electric Welding Machines, Ltd., was elected Chairman for the year 1947 to 1948. In his address he pointed out that the use of resistance welding in this country was by no means fully developed, and considerable economies could be effected by the wider and more effective use of the process. Mr. F. Simmons, of the British Federal Welder and Machine Company, Ltd., was elected Chairman of the Technical Committee, and Mr. E. S. Waddington, of Philips Industrial, Ltd., was elected Chairman of the Trading Committee.

Industrial Applications of Electronic Techniques*

By H. A. THOMAS, D.Sc., M.I.E.E.

No. III—(*Continued from page 272, March 28th*)

Electronic Heating.—Heating is an important factor in a large number of industrial processes; it may be produced by conduction, convection or radiation from an external source, or, alternatively, it may be generated electrically within the material by passage of an electric current. Three forms of internal heating are available :—

(*a*) Resistance heating, in which a conduced current produces the heat.

(*b*) Eddy-current heating, in which an induced current is used.

(*c*) Dielectric heating, in which a displacement current is utilised for heat generation.

Resistance heating does not involve electronic devices and need not be discussed. Eddy current heating is used for melting metals by subjecting the material to an alternating magnetic field and using the power absorbed by the flow of induced current to raise the temperature. Dielectric heating is used when the material is a poor electrical conductor, by subjecting it to an alternating electric field and making use of the power absorbed in the dielectric to raise the temperature. In both eddy-current and dielectric heating comparatively high-frequency currents are employed, the generation of which involves the use of thermionic valves. It is for this reason that such heating methods are usually referred to as electronic, though strictly they should not be considered as such. A very considerable literature is already available on this subject, [4, 10, 23, 26, 37, 38, 44], and the author intends only to mention some of the salient features of these important methods of heating to draw further attention to their applicability in many industrial processes.

Eddy-Current Heating.—To heat electrical conductors such as iron, aluminium, brass, &c., the material is surrounded by a coil carrying an a.c. This coil induces heating currents in the material, the process being termed induction heating and the equipment an induction furnace. For efficient operation the material to be heated should be fully enclosed by an inducing coil, which is usually water-cooled.

The method may be employed for annealing metal tubes and sheet, for welding pipes, for brazing tool tips and other products, for forging bolt heads and rivets, for hot spinning, for melting alloys, such as tin, for spot annealing, for surface hardening of gears, shafts, cylinders and for soldering.

Soldering is a particularly good application of eddy-current heating[37] because, owing to the comparatively low temperatures required, the inducing coil can usually be arranged to provide local heat only at the point where it is desired. The mass production of terminal bushings on tin plate condenser cases, of end caps on silvered glass tubes, of lugs on cables, and wires on cartridge type fuses, are all examples of jobs which can be performed rapidly by eddy-current heating.

An example of automatically soldering the ends on to tin plate cans is illustrated[38] in Fig. 12. Each can with its base in position has placed at the bottom a loop of resin-cored solder shaped correctly just to drop into the can. The cans are carried by a travelling belt through an inducing coil carrying 3 kW at 10 Mc/s; the coil is shaped to melt the solder at a certain point in the transit and then to provide reduced heating for a time sufficient to permit easy flow of the solder.

The tinning of electrolytic tin plate is another example of low-density heating. At a frequency of 200 kc/s with a strip running at 1000ft per minute a surface density of 240 watts per square inch can be provided with the expenditure of 1200 kW. Methods such as these can be applied in many industrial problems of repetition heating.

Dielectric Heating.—Dielectric heating consists essentially of subjecting the material to an alternating electric field and using the absorption of power in the material to increase the tem-

* Abstract. Institution of Electrical Engineers, January 16, 1947.

perature. If a slab of dielectric material be interposed between two parallel flat electrodes the capacitance will be increased and the power factor will not be zero. It can be shown[10] that the heat generated is a linear function of the product of the permittivity and power factor, called the "loss factor" of the material.

The great merit of dielectric heating is illustrated in Fig. 13.[33] In the top figure the internal temperature of a 6in slab of wood heated by direct contact with steam platens is shown against time of application, from which it is seen that the centre is not completely heated until a period of about ten hours has elapsed. In the lower figure the internal temperature reaches its final value in four minutes.

The advantages of dielectric heating are that it produces a result not possible by other methods, it increases the speed of the heating process, it confines the heating to the part needed and it is clean and compact. On the other hand, it must not be assumed that the method is always superior to mechanical methods of drying. For example, it requires 4000 kWh to remove moisture from heavy cloth which could be removed by a mangle with an expenditure of only 4 kWh. There is a limit, however, to such mechanical methods of drying.

In the textile and paper industries moisture is removed by passing over heated drums or

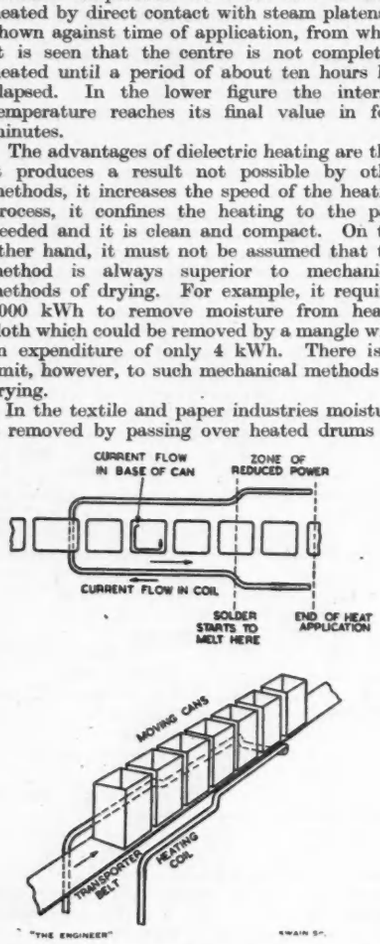


FIG. 12—*Automatic Soldering of Tin-Can Bases*

through forced-convection dryers, and it is unlikely that electrical methods will prove so economical, but in the production of glued plywood, the curing of rubber and the softening of plastics the internal heating which can rapidly be obtained by dielectric heating is so great an advantage that there is no satisfactory alternative. Furthermore, the method opens up new possibilities in connection with the cooking, sterilisation and dehydration of foodstuffs, in the cementing of furniture to take the place of glue joints and in the production of new materials comprising paper with resinous or plastic impregnation, or compressed wood impregnated with resin.[26]

In the working of refractory materials such as glass or quartz local dielectric heating may be used with good effect. Glass may be heated externally by conventional glass-working fires, or internally by dielectric heating. The latter avoids surface boiling and the loss of volatile constituents, but owing to the very low loss factor of glass when cold the internal heat which can be produced is rather small. This disadvantage can be overcome by use of special electrodes which emit from their points a very small oxy-hydrogen flame.[21] The two combined electrodes and burners are played locally on to the work to be softened until the glass is dull red and the loss factor appreciably increased. The radio-frequency energy is then switched on and intense local heating is produced by internal dielectric currents. The small oxy-hydrogen burners not only serve to preheat the work and restrict the volume which is heated by dielectric current, but also act as gaseous conductors, which direct the radio-frequency energy to the desired local point of heating; they serve in fact as flexible non-sticking electrical conductors. By skilful manual handling of the electrodes a variable resistance in series with the glass load is provided so that regulation of temperature is readily obtained without intense surface heating.

Inspection

Electronic devices have wide application in the inspection and testing of industrial products. A few only of these applications can be mentioned here by way of illustration.

Counting.—Counting of small parts produced by rapid repetition processes, paper sheets, ball bearings, &c., can be effected very simply by interruption of a light beam arranged suitably with respect to the moving parts. A normal type of photo-electric cell detector may be used with a Veeder type counter for interruption rates not greater than 10 per second, and uni-

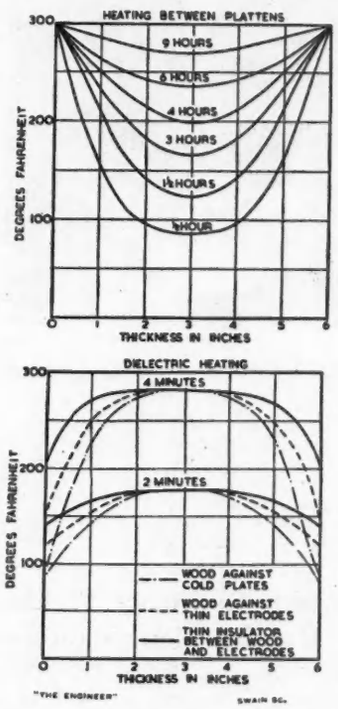


FIG. 13—*External and Internal Heating of Wood*

selector counters may be used for impulse rates up to 50 per second.[24]

The supply needed to heat the cathode of the valve can be eliminated by adopting a cold cathode valve.[2] In such a valve application of a positive voltage to the grid initiates discharge, but removal of the voltage does not cause its cessation; to make the anode current dependent on the grid voltage use may be made of the scheme[2] illustrated in Fig. 14A. Here, with positive grid volts the valve behaves as a discharge tube, and relaxation oscillations occur at a frequency controlled by the value of R and C; when the grid is not positive oscillation will cease. For photo cell application the circuit shown in Fig. 14B can be adopted, which operates the relay on interruption of the beam. The advantages of such cold-cathode valves is that no power is expended when the grid is at zero potential, and the valve is always in readiness to receive impulses.

Such relay systems are suitable for the majority of industrial counting purposes. For counting impulses of much higher rates, decimal counters [24, 53] involving pulse-dividing circuits may be utilised.

Uniformity of Surfaces and Thin Sheet Materials which can be Inspected Optically.—Any material of a translucent nature, the light transmission characteristics of which are dependent upon uniformity, may be inspected by passing the material between a light source and a photo cell and integrating the variations in light intensity. Similarly, if the uniformity of a surface can be defined in terms of its optical reflection coefficient, integration of the variations in reflected light incident on a photo cell can be used to assess the uniformity of the surface.

The principle can be applied to the detection of unevenness in high-grade paper, in coatings of paint and resins on opaque surfaces, in enamelling on metals, &c., and can be made very sensitive by suitable design of the optical system.

Inspection of Holes in Machined Parts.—Electronic devices may be used for inspecting small holes in repetition parts by passing a light beam through the hole and observing the response obtained with a photo-electric cell, the response being made subsequently to actuate mechanism which rejects a faulty part.

A particular example[55] of the manner in which this can be accomplished is shown in Fig. 15. In this case, correct drilling of a lubricating oil hole in a shackle bolt is being inspected. Each bolt in turn is located with respect to a light beam. When located, the bolt is rotated by a continuously running wheel, and if the hole is clear a pulse of light falls on to the photo cell, but if the hole is blocked for any reason no pulse is received. This pulse is

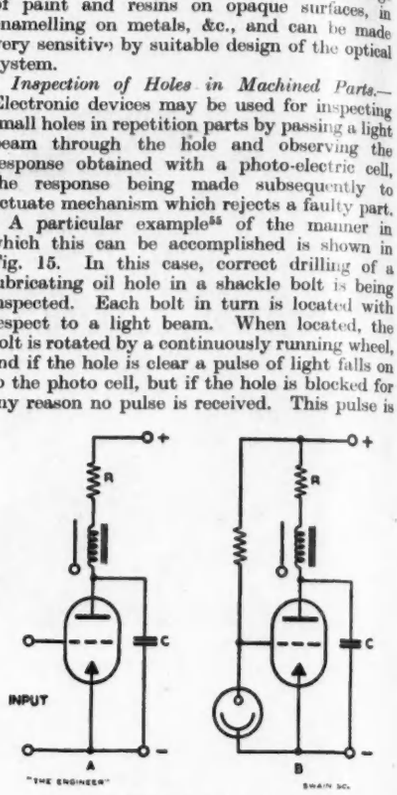


FIG. 14—*Cold-Cathode Counter Circuit*

used to operate a relay controlling a device, which, on further rotation of the index wheel, drops faulty bolts in a "rejection" bin.

This is a simple application of optical inspection. The diameter of small holes, such as in carburreter jets, can be inspected by like means, and numerous opportunities occur in the inspection of machine parts for applying this principle.

Automatic Gauging.—Automatic gauging of repetition parts can be effected by a number of methods. Any of the methods for detecting small linear displacements, as described above can be applied.

For example, in the inspection of parts machined to small tolerances, each part can successively be dropped into a jig fitted with small electrodes, each of which is adjusted to give a particular value of capacitance corresponding to each correct dimension. Each of these capacitors can be associated with an oscillator, frequency discriminator, and a relay system so arranged that the existence of any dimension greater or smaller than a predetermined value actuates a corresponding relay and provides an indication of the exact nature of the fault. Furthermore, the relay system can be arranged to control mechanism which, on further travel of the component along an inspection line, drops it into an appropriate rejection bin containing parts which are all rejected for the same type of fault.

This principle can be applied to the inspection of almost any property of a large number of similar components, and by suitable design of the automatic inspecting equipment a great saving in manual labour can be effected.

Surface Finish.—Inspection of surface finish is of great importance in cylinder manufacture, surface plates, reflecting surfaces, &c., and various methods are available.

The surface may be inspected visually with or without optical aids, it may be examined by feel and finger-nail tests or by microscopic

examination of cross section. Possibly the best method is to use a tracer instrument consisting essentially of a very hard and small stylus which is drawn slowly and lightly over the surface under inspection. The stylus is made small enough to follow irregularities in the surface, and the movements, after suitable amplification, are recorded or integrated to give a measure of the surface finish.

The stylus consists usually of a diamond-tipped needle of radius about 0·01in. This is drawn slowly over the surface, and the small movements arising from unevenness are amplified electrically. There are three ways of transforming the mechanical motions into electrical potential :—

(*a*) By electromagnetic induction, in which the stylus movement produces a small e.m.f. in a moving coil.[5] In this case the voltage generated is proportional to the rate of movement of the stylus and not to the actual deflection. It is not therefore a true linear recording device.

(*b*) By the generation of an electrical potential proportional to displacement, by means of a piezo-electric crystal. In one form of this method[18] a Rochelle salt crystal has been used, requiring a load of 0·1 g to give 1·2 mV/10^{-6}in. The sensitivity of the method is very high, but the load on the stylus is considerable and the displacement is limited to very small magnitudes.

(*c*) By variation of frequency. This latter

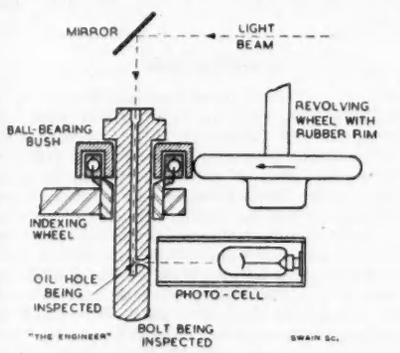


FIG. 15—*Oil Hole Inspection*

method is the most satisfactory, since it gives negligible zero creep, negligible loading on the stylus at all displacements, and high sensitivity.

In one practical form of this method[9] frequency variation of a crystal-controlled oscillator operating at 1·6 Mc/s is provided by variation of air gap. The frequency change is about 0·3 c/s per micro-inch. This frequency is quadrupled to 6·4 Mc/s, and comparison is made with a fixed-frequency oscillator. A frequency changer, 100 kc/s intermediate-frequency amplifier, limiter, frequency discriminator, giving an output of 62 mV/10^{-6}in, low-frequency amplifier, and pen recorder completes the equipment. The stylus is motor-driven across the specimen at a rate of 0·03in per minute, while the pen recorder produces an inked record of the surface contour. Alternatively, an integrating circuit may be brought into operation, in which case the rate of traverse is increased to 0·33in per minute and an integrated record of the degree of unevenness is obtained.

Miscellaneous Inspecting Devices.—Rapid indication of the presence and depth of cracks in ferrous and non-ferrous materials can be achieved by passing the material through a radio-frequency coil forming part of a tuned circuit.‡ Alteration of frequency due to the presence of a crack is utilised to operate frequency selective relays controlling a visual indicator, and the depth of the crack is indicated on a dial.

The detection of pin holes in the enamelling on copper wire can be undertaken rapidly by passing the wire through a mercury bath and counting electrically the number of times the current flows between the wire and the bath.§

‡ Salford Electrical Instruments, Ltd.

§ Salford Electrical Instruments, Ltd., and British Physical Laboratories.

The presence of small foreign metallic bodies in foodstuffs can be detected by passing the material through a radio-frequency coil and observing either the change in frequency or change of resistance produced by the foreign body.

Many more examples of electronic aids to inspection could be enumerated. Those briefly mentioned are merely illustrative of the versatility of such methods. There is practically no problem of mass inspection to which some electronic aid cannot be applied.[19] The designer has only to consider whether the introduction of such devices is economically justifiable.

Protection

[Here the author outlined the principles of burglary protection, and described a modulated beam photo-electric intrusion detector, in which a wide variation in ambient light is permissible, so that the practical difficulty of maintaining alignment and cleanliness of the optical system is overcome.]

Fire Protection.—Fire can be detected and an alarm given by using a temperature-sensitive device and associated electronic equipment. If such devices are adjusted so as not to operate with normal ambient changes of temperature they are usually rather insensitive. Early warning is more readily provided by detecting the presence of smoke. In the arrangement[54] shown in Fig. 16 two photo cells are arranged so that normal illumination keeps open the relay contacts. The presence of smoke in the path of the beam increases the resistance of cell B, so lowering the grid voltage and closing the relay contact. The particular smoke detector illustrated in Fig. 16 is designed for measuring smoke density in flues and stacks. In such an application the main problem is "scavenging"—keeping clean the projector and receiver windows. Various methods, such as blowing air on the protecting glass windows and water spraying, have been developed.[49]

A more recent fire-detecting device employs a differential thermometer which actuates the alarm only when the rate of rise of temperature exceeds 10 deg. Fah. per minute—the system is unresponsive to ambient temperature changes.

Danger of explosion through gas failure can be eliminated by automatic means of cutting-off the supply in the event of failure.‖ One method makes use of an electromagnetic gas valve held open by the current generated in a thermocouple heated by a pilot jet. On failure of the gas supply the couple cools and the main valve is closed. Another method‖ makes use of the fact that the ionised envelope around a flame is partially conducting. By the introduction of an electrode in a pilot flame a small current between this electrode and the body of the burner can be utilised to hold open a relay in an electronic system. Failure of the gas supply immediately cuts off this current and closes the main gas valve.

Accident Protection.—There is a wide field of application for electronic devices for the protection of operatives in mines and general engineering processes. In the operation of lathes, saws, presses, guillotines, drills, millers, &c., devices can readily be developed to shut off the power should the operator introduce a portion of his body into a dangerous position. Usually such devices take the form of light beams disposed in such a manner that interruption trips the control mechanism.

Conclusion

The brief descriptions of some electronic devices of value in industrial processes given in the preceding sections illustrate the versatility of electronic techniques. More intensive application to industry depends primarily upon a greater appreciation of the utility of such devices and upon careful consideration of the economics of each particular problem.

To assist manufacturers of electronic equipment in assessing the possible future markets for such products, reference may be made to a recent survey conducted in 1944 and 1945 by the research department of the McGraw-Hill Publishing Company,[60] in which an attempt has been made to ascertain the extensiveness of the present applications of electronic devices to particular industries and the problems which are likely to be solved by future applications of electronic techniques. In the survey, 1300 questionnaires were distributed to selected manufacturers in America, and the rather poor response of only 4·2 per cent was analysed statistically. From such a poor response it is admitted that the survey is far from complete, and that the results obtained should not be interpreted too literally, but, nevertheless, it represents the study of the subject to date.

While certain specific industries are larger users of electronic apparatus than others at the moment, the interest shown by non-users indicates that the potential applications are very considerable and are likely to be found in almost all industries. Furthermore, it is pointed out that, despite the publicity given to electronic techniques in numerous publications, many industries are still unaware of the present capabilities of such techniques.

The author is of the opinion that there is need for a publicity campaign to make industry fully aware of the potentialities of electronic applications and that such a campaign could with great advantage to many industries in the country be sponsored by a new organisation

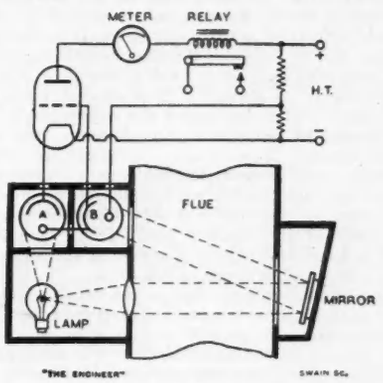


FIG. 16—*Smoke Detector*

devoted entirely to the exploration of possible fields of application.

‖ Honeywell-Brown, Ltd.

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Industrial and Labour Notes

The T.U.C. and the Economic Survey

The general council of the Trades Union Congress was in session on two days last week, and devoted much of the time to matters arising from a report presented by the committee set up a few weeks ago to consider problems relating to the fuel and power crisis and the economic situation generally. A statement made after the meeting said that the general council does not propose at this stage to publish the committee's report, but expects that its recommendations will be the subject of discussion with the Government.

The statement gives, however, some indication of the general council's views upon the "Government's Economic Survey for 1947," and upon the situation created by the fuel shortage. It says, for instance, that while the change-over from war to peace proceeded in a remarkably smooth fashion up to the latter half of 1946 "we have now reached the point at which we have outrun the capacity of our basic industries to meet the demands put upon them and the effect of starving those industries of essential equipment over a period of years has begun to show." The general council observes that it has urged the widest possible extension of production committees to further the general improvement of industrial efficiency, and, later in the statement, expresses the view that the White Paper targets certainly appear low if considered only from the point of view of the obvious need of this country for a large and speedy increase in the supply of goods and services of all kinds. It is not considered, however, that in general those targets can be criticised on the grounds of insufficiency, for, the general council says, in view of present difficulties "the need is to frame targets which our resources would permit us to achieve within the set time."

As the progress of our whole economy is limited by weaknesses in certain basic industries, the general council feels that some other measures of an emergency nature will need to be initiated and steps taken to increase, within the very near future, the capacity of the coal, electric power and rail transport industries. The opinion is advanced that the target for the 1947 coal output should be set at a higher figure than 200,000,000 tons. A long term figure suggested by the general council is 250,000,000 tons, with a target of 220,000,000 tons for the present year "in order that the expansion of industrial production shall not be unnecessarily limited in the immediate future." At the same time, it is emphasised that there must also be an increase in the capacity of the railways and electricity supply industry so that the coal may be transported and converted into power. Here, it is considered that the continuation of the present arrangements and economies for spreading the electricity load cannot be contemplated for a period as long as two or three years, and unless something is done in the very near future to maintain and increase the capacity of the railways, production of coal and steel will be held up for lack of transport. In view of the need for an urgent programme of mechanisation in the mines and of equipment for the railways and electricity supply industry, the T.U.C. advocates immediate Government consultation with both sides of the engineering industry on the matter.

Other comments made in the statement are that the general council welcomes the Governments intention to establish the facts about output and productivity. On the question of hours, however, it claims that in many cases it has been found that a reduction to forty-four hours per week "is likely to increase output over a period." Moreover, the statement ends, "it would be unfair and impossible to expect work-people in industries still working a forty-eight-hour week to abandon their claim to improvement which was already well advanced when the White Paper was published."

The Joint Planning Staff and Research

The Prime Minister was asked recently in Parliament if he would set up a scientific and technical sub-committee of the joint planning staff as an integral part of the proposed planning machinery. The suggestion was that it should carry out research on lines similar to those adopted by the joint technical warfare committee and should advise the Government as to methods by which the results of modern technical development could be applied with a view to raising the productivity and efficiency of industry.

Replying, the Prime Minister agreed that scientific and technical research was of the highest importance to productivity and industrial efficiency, and pointed out that there were existing agencies for studying these matters. There were the Scientific Advisory Council and the Department of Scientific and Industrial Research, and it had been the active policy of the latter department, the Prime Minister said, to get all kinds of organisations set up within industry. He did not see how the proposal for a new sub-committee would really cure the position for firms which were indifferent to the opportunities already existing. The Prime Minister assured the House that the proposed joint planning staff would make full use of the existing research facilities, and he did not think it desirable to set up a new organisation.

Tin, Copper and Lead Prices

At the end of last week, the Ministry of Supply announced increased selling prices for tin, copper and lead. Tin metal of minimum 99 per cent up to under 99·75 per cent tin content has been increased in price from £380 10s. to £437 per ton. All other prices have been varied correspondingly. The new price became effective on March 28th.

By the Control of Non-Ferrous Metals (No. 28) (Copper, Lead and Zinc) Order, which came into force on March 31st, the maximum price of high-conductivity electrolytic copper has been increased from £127 to £137, and of lead (good soft pig lead, Empire and domestic) from £70 to £90 per ton. Prices for other descriptions of copper and lead have been correspondingly adjusted. There is no change in the price of zinc and zinc products.

Any inquiries relating to the new prices of tin, copper and lead should be addressed to the Directorate of Non-Ferrous Metals, 20, Albert Street, Rugby.

The Government's Fuel Economy Proposals

A statement on the fuel position was made in the House of Commons by the Prime Minister, Mr. Atlee, on Thursday of last week, outlining the methods of fuel economy which the Government proposes to adopt in the coming months. Mr. Atlee said that coal consumption for the six month period May to October had been estimated at 92,000,000 tons to which a figure of 10,000,000 tons must be added if stocks were to reach 15,000,000 tons by November 1st. From this total, 2,000,000 tons could be deducted as the saving which it was hoped to achieve by the coal-oil conversion programme.

The Prime Minister stated that the Government was pressing ahead with all possible measures to increase coal production, and that the National Coal Board, with the co-operation of the miners' leaders, was taking every step to secure increased output per man-year. All the steps being taken, however, could only bear fruit gradually, and the Government did not consider it prudent, in preparing plans for the immediate future, to count firmly on a production during the six summer months of the amount of coal required. The deficiency, Mr. Atlee thought, might amount to as much as 10,000,000 tons.

With regard to economy, the Prime Minister said that railway passenger services this summer would be reduced by 10 per cent, compared with last summer, thus effecting a saving of 250,000 tons of coal. Such measures as were possible for reducing still further the export of coal, whether for bunkering of ships or other purposes, would be taken and should it prove possible to import coal without unfairness to other European countries, this would be done. But, the Prime Minister continued, there would still remain a serious gap, and the Government's view was that domestic and non-industrial consumers, as their contribution, must aim at saving 2,500,000 tons of coal during the summer. The Government had examined a number of alternative schemes for rationing electricity and gas, but it had found that all of them would be complicated and difficult to enforce. It was proposed, therefore, to apply restrictions on the use of gas and electricity for heating rooms in residential premises during the summer, and, with some variation, to maintain the existing prohibition on the use of electricity for cooking and water heating during certain hours each day. This prohibition would be extended to gas, and details of all the restrictions, the Prime Minister intimated, would be announced shortly.

Manpower and Materials

At the annual meeting of the English Electric Co., Ltd., in London last week, the Chairman, Sir George H. Nelson, said that the company had done everything in its power to meet the wish of the Government to assist the export drive by obtaining contracts from abroad for capital goods. With full approval of the Government departments concerned and on the assurance that additional labour and a balanced flow of materials would be available, the company, Sir George reported, had embarked on important extensions to its works and had raised substantial new capital to pay for them. That policy was undoubtedly the right policy, but the company had met with many delays and disappointments in carrying it out.

Dealing with the cumulative effects of disappointing manpower and material supplies, Sir George asserted that they called for urgent and positive treatment in which neither the Government nor industry could hope for success in isolation. The basis of rectifying the situation was that the first things must now come first. Sir George's conviction was that we—and by "we" he meant the Government and industry—must concentrate on ensuring that the best possible use was made of available labour and materials. We should have to compress and organise our national effort before we could expand it as our long-term needs required that it should be expanded. At present, as a nation, Sir George thought that we had oversold our production capacity, and we must see that by joint action we brought our commitments, week by week and month by month, more into line with available resources.

To do that, Sir George contended, would involve discussions within and between industries and the Government, and decisions which were often difficult and distasteful on the allocation of material as between one industry and another, so that labour could no longer be attracted by shorter hours or higher wages into activities of minor importance. It would also involve more searching scrutiny of applications for building licences for factories. It would also require the abandonment of the pursuit of conflicting policies by different departments. Sir George believed that our difficulties had been aggravated by the diversion of many of the ablest minds in the Civil Service from the pressing tasks of administration, in which their experience and competence were invaluable, to the political and legislative problems of nationalisation which were of no more relevance to present troubles than an expedition to Mars!

French Engineering News

(From our French Correspondent)

PARIS, March 28th.

The Petrol Régie is continuing its researches, and out of six soundings now being taken, almost all have attained a depth of 2000 m or more. Gas soundings are now being exploited at Saint-Marcet, where there are now six gas-producing shafts. Pressure is 136 kg to 138 kg and 30 to 40 grammes of spirit are extracted per cubic metre. In 1948 a gas extractor capable of treating 1,200,000 cubic metres of gas in twenty-four hours is to be set up at Boussens. A 313-mm pipe line (pressure 60 kg) was started between Boussens and Toulouse in December. According to the Ministry of Industrial Production, natural gas produced in December was 10,361,000 cubic metres against 10,328,000 cubic metres in November.

The new Tarbes–Paúl pipe line, 42 km long and 140 mm diameter, is now in service as an extension to the pipe line between Saint-Marcet and Tarbes. The work was carried out in less than four months, making an average of 400 m completed per day. This pipe line will distribute 7000 to 8000 cubic metres of natural gas daily, mixed with water gas in such a way that domestic equipment will not have to be modified. A compressor station for gas-equipped vehicles will comprise two compressors, each with a capacity of 300 cubic metres an hour.

* * *

The second price reductions recently decreed in France are not to be uniformly applied, as were the first. The Government has exempted certain products from the second cut as using too much labour in relation to materials, and in cases such as steel and pig iron, the question is to be specially considered, because prices will rise automatically by 24 per cent to 36 per cent as a result of the withdrawal of subsidies on fuel. A special ruling will also be applied for the production of certain metals and ferrous-alloys where prices have not risen more than 200 per cent since 1939. Prices for certain steel and mechanical products will be fixed by the Ministries of National Economy and Industrial Production. It is hoped that industrialists will be encouraged to release their stocks by the order which states that present stocks may be sold during the next three months at prices prevailing on January 1, 1947. After that time the full cuts will take effect.

* * *

A table has just been issued showing the electric power consumption by industry during 1946. The mining and metallurgical industries, which used a monthly average of 262 million kWh in 1938, used 253 million units in January, 380 million in April, 411 million in June, 404 million in July, 360 million in August, and 325 million in October. The mechanical and electricity industries in no month consumed less than 81 million kWh in 1938, the average being well over 100 million. Consumption by the construction materials industry, which was 28 million units in 1938, rose steadily from 31 million in January to 50 million in October. All the industries mentioned were given priority in their allocations of power.

* * *

The Labarre hydro-electric plant, recently put into service, is situated on the Arriège, near Foix, and is fed from a reservoir holding 500,000 cubic metres of water, over an 11·5 m fall. Maximum flow is 50 cubic metres a second, and maximum electrical output is 5500 kW. The dam, which is 15·5 m high and 70 m long, is a reinforced concrete structure with three flood gates, each measuring 8 m by 5 m. The main turbo-alternator group comprises a vertical-axis 200 r.p.m. Kaplan turbine and a 5·5-kV, 50-cycle, 5000-kVA, three-phase alternator. The transforming station includes a 5·5/60 kV, 5000 kVA transformer. Starting of the plant was delayed owing to a technical hitch, the installation of the turbine and alternator being rather delicate. One bearing had to be replaced. The plant, however, has a particular interest from the technical point of view in that it has a tail-race chamber cut out of solid rock.

Notes and Memoranda

Rail and Road

MOTOR VEHICLE REGISTRATIONS.—New registrations of motor vehicles in Great Britain during 1946 totalled 343,365, of which 119,424 were private cars.

SWEDEN'S AUTOMOBILE INDUSTRY.—Between 1935 and 1939 the number of motor-cars registered in Sweden increased from 160,000 to 250,000. This upward trend was interrupted during the war years, during which the number of cars in service had to be reduced by two-thirds. At present, motor traffic is reported to be rapidly increasing again, and on January 1st of this year the number of motor-cars registered in Sweden was estimated at 200,000.

BELGIAN RAILWAYS ROLLING STOCK.—At the end of last year, the Belgian National Railways owned 3350 locomotives, 2325 of which were in service. With regard to goods wagons, statistics show that the present total is 83,000, a figure considerably below pre-war level. Considerable losses of passenger vehicles were caused by war destruction, and in the case of modern steel coaches amounted to 300 out of a total of 1574 owned by the Belgian National Railways.

BRITISH RAILWAY FACTS.—The British Railways' Press Office, 2, Palace Chambers, Bridge Street, S.W.1, has recently issued a new edition of the booklet entitled "British Railways Facts and Figures." The booklet contains a multitude of interesting facts and figures about the British main line railways and the London Passenger Transport Board, all the main items being arranged in alphabetical order. The outstanding events of railway history are tabulated in chronological order, and at the end of the booklet, a useful glossary of railway terms and an "Anglo-American" glossary have been included.

WAGON SHORTAGE ON U.S. RAILWAYS.—Recent reports stress the serious shortage of goods wagons which the United States Railways are making strenuous efforts to overcome. Since the end of the war, goods wagons have worn out at an unprecedented rate. By the beginning of this year, something like 5000 to 7000 a month were being taken out of service for scrap, and replacements in January numbered only 2800. According to the Association of American Railroads, wagons owned by the railways in February, 1947, totalled 1,739,060, compared with over 1,800,000 early in 1944. It is hoped by means of bigger steel allocations to manufacturers to increase output of wagons to 10,000 a month by June, the rate generally regarded as necessary to prevent the shortage from getting worse.

Air and Water

SWEDISH SHIPBUILDING.—At a recent meeting of the Swedish Committee of Lloyd's Register, it was reported that sixty-five ships, aggregating 244,255 tons gross, are at present under construction or being fitted out at Swedish shipbuilding yards, and another 175 ships, aggregating 976,250 tons, are on order. Of this total of 240 vessels, 100 of 361,455 tons gross are for Swedish owners.

NORWEGIAN SHIPPING AGREEMENT.—An agreement was signed in London on March 27th, disposing of all major outstanding claims arising out of the wartime chartering to the British Government of Norwegian merchant ships. The claims and counter-claims by the British Government and the Royal Norwegian Government, under the agreement, are roughly equivalent, the total amount payable by each party to the agreement being approximately £2,500,000.

FIREPROOF FINISHES FOR AIRCRAFT FABRIC.—A report on the fireproofing of fabrics, issued recently by the Department of Scientific and Industrial Research, sets out the results of research work carried out at the Royal Aircraft Establishment, South Farnborough, under the direction of Dr. J. E. Ramsbottom. Dealing with fireproof finishes for aircraft fabric, it says that these involve consideration of the nature of the tautening dope with which the fabric is treated in order to present an outer surface on aircraft having the desired aerodynamic properties. A general assessment of the fire risks associated with fabric covered aircraft is given. No satisfactory fireproofing treatment was found for fabric to be coated with nitro or acetyl cellulose dope, but with dopes made from chlorpolyvinyl chloride previous treatment of the fabric with 20 per cent by weight of ferric or stannic oxide gave a permanently fireproof effect. The report is published by H.M. Stationery Office, price 2s. 6d.

HYDROLOGICAL SURVEY IN UGANDA.—The Colonial Office announces that Mr. C. G. Hawes has arrived in Uganda from the United Kingdom to advise the Uganda Government on questions relating to the hydrology of the Lake Victoria basin area. He will be particularly concerned with investigating the possibility of the provision of facilities for the generation of hydro-electric power on a very large scale for use over a wide area of Uganda. The building of a dam at Jinja is under consideration, and such a dam, if erected, would present an excellent opportunity for the development of hydro-electric power in almost unlimited quantities at a reasonable cost. This development of hydro-electric power must take place within the next few years in any case, although in the absence of any scheme for the control of Lake Victoria, it would be on a smaller scale and might be more costly to Uganda. It is explained that the use of Lake Victoria for water storage purposes should not cause any serious disturbance. At the most it will not necessitate a rise in the lake level of more than 3ft above the maximum recorded level, and it will take the best part of twenty years after completion of the dam before it rises to such a level. A further advantage to Uganda, if such a scheme were to be undertaken, would be to ease the problems of lake transport not only on Lake Victoria but also on Lake Kioga, since comparative stability of water levels would enable ports to be made accessible to lake steamers at all times of the year.

Miscellanea

COMBINE HARVESTERS.—A written reply by the Minister of Agriculture states that in the production year October 1st, 1945, to September 30, 1946, there were 126 combine harvesters manufactured in this country, 125 of which were supplied to the home market. The Minister added that production for the 1947 harvest was expected to be over 600 and that about 90 per cent of this total would be supplied to the home market.

BOOKS FOR GERMANY.—An appeal is being made for books and periodicals on educational, technical, political and economic subjects, which can be circulated in Germany. They are needed, in the interests of the re-education of the German people, and details of the scheme will be supplied by the Secretary, German Educational Reconstruction, 15, James Street, Long Acre, W.C.2. The project has been organised with the full approval of the Control Office for Germany and Austria.

TUNGSTEN ORE.—The Ministry of Supply announces that as from March 28th the price of tungsten ore of standard grade from Government stocks is 100s. per unit of WO_3 delivered consumers' works. For special high grade Scheelite to the following specification—WO_3 minimum 68 per cent, tin maximum 0·60 per cent, arsenic maximum 0·10 per cent, molybdenum maximum 0·10 per cent, the price is 105s. per unit WO_3 delivered consumers' works. Any enquiry regarding this matter should be addressed to Ministry of Supply (M2), Shell Mex House, Strand, London, W.C.2.

OLD CENTRALIANS' MIDLAND BRANCH.—The newly-formed Midland Branch of the Old Centralians, held its first annual dinner in Birmingham on March 15th. Mr. J. P. Clifton, the branch Chairman, presided, and the guests included Mr. F. H. Bramwell, President of the Old Centralians, and Mr. J. Wood, Chairman of the Midland branch of the Institution of Mechanical Engineers. Any Old Centralians in the Midland area who would like to join the branch are invited to communicate with the honorary secretary, Mr. A. A. Blanco, 2, Woodlands Park Road, Kings Norton, Birmingham.

SWEDISH POWER TRANSMISSION LINE.—A new power transmission line, claimed to be the longest of its kind in the world, is to be built from Harspranget, the large power station now in course of construction in North Sweden, to Hallsberg, in the central part of the country—a distance of about 600 miles. The line, consisting of S.C.A. conductors, is intended for 380-kV alternating current. By this line Harspranget, situated North of the Arctic Circle, on the Lule River, will be connected with the power-distributing network in the central and southern parts of Sweden. The power station systems on the Indalsälven and Angermanälven, two other big rivers in North Sweden, will also be linked up with the new line *vid* the Midskog station. The power line, the cost of which is estimated at about £4,900,000, will probably be completed at the end of 1950, at about the same time as the first turbo-generator set at Harspranget.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, April 15th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Light and Colour as Applied to Works Equipment," W. Robinson. 6.15 p.m.

British Interplanetary Society

Saturday, April 12th.—Science Museum, South Kensington, S.W.7. "Cosmic Rays," Lion 1 Gilbert. 6 p.m.

Illuminating Engineering Society

Friday, April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "Portable Photometers," J. S. Preston. 6 p.m.

Institute of Economic Engineering

Thursday, April 10th.—MIDLAND REGION: Chamber of Commerce, Birmingham. "Evaluation of Time Study Data," J. R. Whitby. 7 p.m.

Institution of Civil Engineers

Thursday, April 10th.—BIRMINGHAM ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Water Purification," W. S. Thompson.

Institution of Electrical Engineers

Wednesday, April 9th.—SCOTTISH CENTRE: Heriot-Watt College, Edinburgh. "Comparisons between Gas and Electricity on the Basis of Coal Economy," P. Schiller. 6 p.m.

Friday, April 11th.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh Luncheon. 12.30 p.m.

Monday, April 14th.—S. MIDLAND CENTRE: Midland Institute, Paradise Street, Birmingham. "The Generation and Wholesale Distribution of Electricity," J. Hacking. 6 p.m.

Tuesday, April 15th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Does Standardisation Conflict with Progress?" 5.30 p.m.

Tuesday, April 22nd.—SCOTTISH CENTRE: The Royal Technical College, George Street, Glasgow. "The Grid System in Wartime," J. Hacking and J. D. Peattie. 6.15 p.m.

Wednesday, April 23rd.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "New Possibilities in Speech Transmission," D. Gabor. 5.30 p.m.

Institution of Factory Managers

Wednesday, April 16th.—S.E. LONDON BRANCH: Bonnington Hotel, Southampton Row, W.C.1. "Education for Management," Colonel L. Urwick. 6.45 p.m.

Institution of Mechanical Engineers

To-day, April 4th.—SCOTTISH GRADUATES: Royal Technical College, Glasgow. "The Machinery of an Oil Cake Mill," R. M. Smith. 7.30 p.m.

Thursday, April 17th.—WESTERN BRANCH: Merchant Venturers' Technical College, Unity Street, Bristol. "Fluid Couplings and their Applications," A. R. Vickers. 7 p.m.

Saturday, April 26th.—N. WESTERN GRADUATES: Engineers' Club, Albert Square, Manchester. "Electronics for the Mechanical Engineer," K. M. Fantom. 2.30 p.m.

Institution of Mining and Metallurgy

Tuesday, April 15th.—The Royal Institution, 21, Albemarle Street, W.1. "The History and Prevention of Silicosis with Special Reference to the Witwatersrand," Major-General A. J. Orenstein. 5 p.m.

Institution of Post Office Electrical Engineers

Monday, April 28th.—Faraday Building (South Block), Knightrider Street, E.C.4. "Repeater Station Power Supplies," K. W. Hix. 5 p.m.

Institution of Production Engineers

Wednesday, April 9th.—LUTON SECTION: Central Library, Luton. "Shot Peening," W. Neville. 7 p.m.

Thursday, April 10th.—WOLVERHAMPTON SECTION: Station Hotel, Dudley. "Gear Manufacture and Inspection," F. J. Everest. 7 p.m.

Wednesday, April 16th.—MANCHESTER SECTION: College of Technology, Manchester. "Broaching Machines, Tools and Practice," E. Percy Edwards. 7.15 p.m.—SHEFFIELD SECTION: Royal Victoria Hotel, Sheffield. "Stainless Steels," Mr. Tupholme. 6.30 p.m.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Developments in Gear Cutting and Finishing Processes," F. J. Everest. 7 p.m.

Thursday, April 17th.—GLASGOW SECTION: Inst. of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. Annual general meeting. 7.30 p.m.—LEICESTER SECTION: College of Technology, Leicester. Annual general meeting. 6.30 p.m.

Monday, April 21st.—HALIFAX SECTION: White Swan Hotel, Halifax. "Engineering Applications of Polarised Light," J. Ward. 7 p.m.

Thursday, April 24th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Managerial Problems," Mr. Griffin. 6.30 p.m.

Friday, April 25th.—LINCOLN SUB-SECTION: Lincoln Technical College, Lincoln. "X-Rays in Industry," J. L. Mullins. 6.30 p.m.

Junior Institution of Engineers

Friday, April 11th.—39, Victoria Street, S.W.1. "Prestressed Reinforced Concrete," C. E. Reynolds. 6.30 p.m.—WESTERN MEMBERS: Merchant Venturers' Technical College, Unity Street, Bristol. Films, "Valley of the Tennessee," "The Town To-day and To-morrow." 7 p.m.

Friday, April 18th.—39, Victoria Street, S.W.1. "Some Notes on Ropes," R. P. Mears. 6.30 p.m.

Monday, April 21st.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. "Steam Locomotives for Express Traffic on the Railways of Great Britain, 1906–46," C. B. Harley. 7 p.m.

Friday, April 25th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Annual Dinner. 6.45 p.m.

London Association of Engineers

Saturday, April 5th.—Charing Cross Hotel, W.C.2. "Photography in Engineering," G. B. Macalpine. 6.30 p.m.

Manchester Geological and Mining Society

Tuesday, April 15th.—Engineers' Club, Albert Square, Manchester. "Belt Conveyors," J. H. Plumtre. 3.15 p.m.

Newcomen Society

Wednesday, April 16th.—Science Museum, South Kensington, S.W.7. "Windshafts," Rex Wailes; and "The Wind Mills of Hanover," Capt. D. W. Muggeridge. 5.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, April 18th.—Mining Institute, Newcastle-on-Tyne. "Experiments in the Lithgow Propeller Tunnel," A. Emerson and L. W. Berry. 6 p.m.

Royal Aeronautical Society

Thursday, April 10th.—Inst. of Civil Engineers, Great George Street, S.W.1. "A Review of Production Difficulties in Relation to Aircraft Design," C. E. Fielding. 6 p.m.

Thursday, April 17th.—Inst. of Civil Engineers, Great George Street, S.W.1. "Testing Civil Aircraft," P. A. Hufton. 6.30 p.m.

Thursday, April 24th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Risk of Fire and Fire Prevention Methods," J. W. Drinkwater and W. G. Glendening. 6 p.m.

Sheffield Metallurgical Association

Friday, April 11th.—MODERN METHODS OF ANALYSIS GROUP: 198, West Street, Sheffield. "Metallurgical Chromatography," G. Robinson. 7 p.m.

Tuesday, April 15th.—198, West Street, Sheffield. "Origin and Constitution of Certain Non-Metallic Inclusions in Steel," J. L. Rait and H. W. Pinder. 7 p.m.

Tuesday, April 29th.—198, West Street, Sheffield. "Springs for High Duty Purposes," Brinley Jones. 6.30 p.m.

Society of Chemical Industry

Thursday, April 17th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Modern Road Construction in Concrete," W. P. Andrews. 6 p.m.

Society of Engineers

Monday, April 14th.—Geological Society, Burlington House, Piccadilly, W.1. "Research and New Developments in Water Treatment," J. G. Milton. 5 p.m.

Stephenson Locomotive Society

Saturday, April 5th.—EDINBURGH CENTRE: L.N.E.R. Ambulance Room, Calton Hill, Edinburgh. "Locomotives of the Egyptian State Railway," W. Cheyne. 3 p.m.

Saturday, April 19th.—N. EASTERN BRANCH: Central Methodist Church Hall, Newcastle-on-Tyne. "The Churchward Locomotives of the G.W.R.," W. A. Tuplin. 2.30 p.m.

Women's Engineering Society

Thursday, April 10th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester. "Television," N. H. Searby. 6.30 p.m.

Wednesday, April 16th.—35, Grosvenor Place, S.W.1. Discussion, "Equal Pay," 7 p.m.

Launches and Trial Trips

LA HEVE, cargo liner; built by Harland and Wolff, Ltd., for the French Government; length 420ft 6in, breadth 55ft, depth 33ft 6in., gross tonnage 4450. Engines, two-stroke, single-acting, crosshead type diesel, ten cylinders, 620 mm bore by 1150 mm stroke. Launch, February 20th.

MEMNON, cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Egyptian Shipping Company; length 312ft, breadth 44ft 6in, depth 29ft 1in, 3700 tons deadweight. Engines, superheated triple-expansion, with cylinders 19½in, 32in and 56in bore by 39in stroke; boiler pressure 220 lb. Trials completed.

LANGLEESCOT, single-screw motorship; built by Blythswood Shipbuilding Company, Ltd., for the Medomsley Steam Shipping Company, Ltd.; length 460ft, breadth 62ft 6in, depth 41ft 6in., 10,200 tons deadweight. Engines, set of single-screw Doxford opposed-piston, two-cycle, airless injection, six cylinders, 670 mm bore by 2320 mm combined stroke, developing about 6800 b.h.p. Launch, February 25th.

Personal and Business

MR. F. L. CASTLE has been elected President of the Institution of Railway Signal Engineers.

MR. G. P. BARNETT has been appointed H.M. Chief Inspector of Factories in succession to the late Mr. H. E. Chasteney.

PRIESTMAN BROTHERS, LTD., announces that Mr. John Allan, secretary of the company, has been appointed a director.

MR. T. H. SUMMERSON, chairman of Thomas Summerson and Sons, Ltd., has been elected to the Grand Council of the Federation of British Industries.

LORD BRABAZON OF TARA has been re-elected President of the British Electrical Development Association. Sir Leonard Pearce has been elected Vice-President.

ALUMINIUM, LTD., Montreal, announces the formation in Brazil of a new company to be known as Aluminio do Brazil, S.A. It will be owned jointly by Aluminium, Ltd., and Mr. Francisco Pignatari.

A. C. WICKMAN, LTD., has been appointed sole agent in this country, the British Empire and Europe (excluding Russia) for "Hufford" hydraulic stretch-forming machines, designed and manufactured by Hufford Machine Works Incorporated, California.

RICHARDSONS WESTGARTH AND CO., LTD., and its associated companies, The North Eastern Marine Engineering Company (1938), Ltd., and George Clark (1938), Ltd., have concluded a licence arrangement with Sulzer Brothers, Ltd., of Winterthur, Switzerland, for the manufacture of certain types of Sulzer engines.

Reports on German Industry

Limited numbers of copies of the reports of Intelligence Objectives Sub-Committees on German Industry listed below can be obtained from H.M. Stationery Office at the prices stated.

No. of report.	Title.	Post free. s.	d.
F.I.A.T.:			
273	Interview with Dr. J. W. Reppe, I.G. Farbenindustrie, A.G.: Acetylene Chemistry	2	1
274	Report on Illumination	1	7
522	The Beryllium Industries of Germany and Italy, 1939 to 1945	9	3
641	Interrogation of German Scientists Regarding Quartz Crystals and Other Piezoelectric Materials	2	1
697	Rhenium	0	7
734	Report on Velox Boilers	0	7
737	Economic Study of German Synthetic Waxes	3	2
C.I.O.S.:			
VI–28 and 29 and VIII–13	William Prym, Stolberg and Zweifall: Design of Hollow Turbine Blades for Jet Engines	3	8
XXIX–12 (Appendix)	Polyurethanes, Dr. O. Bayer (I.G. Farbenindustrie, Leverkusen): Synthetic Fibres (translation of C.I.O.S. XXIX–12)	2	2
B.I.O.S.:			
546	Melliand Textilberichte, Heidelberg: List of Articles on Textile Auxiliary Products	1	1
572	Investigation into Manufacture and Use of Carbon Black and Lamp Blacks in Germany	10	9
690	German Heavy Electrical Industry: Motors and Power Transformers	3	2
616	Inspection of Krupp-Lurgi Plants for the Carbonisation of Coal at Low Temperatures	4	2
623	Lurgi Gesellschaft Fuer Warmetechnik, Frankfurt-am-Main: (*a*) The Phenosolvan Process; (*b*) The Magdeburg-P Process; (*c*) The Metasolvan Process (the Solvent Extraction of Phenols from Tar Oils with Special Attention to Low-Temperature Carbonisation Oils)	2	1

During the past few months amendments and addenda to the following reports have been issued and made available at H.M. Stationery Office sales offices:—C.I.O.S. Nos. XXVIII–18, XXXIII–23; B.I.O.S. Nos. 35, 135, 199, 217, 307, 340, 345, 363, 405, 422, 423, 429, 438, 450, 468, 507, 572, 591, 773; F.I.A.T. No. 273.

An almost complete set of German patent specifications, accepted by the Berlin Patent Office during the war, has been secured for the United Kingdom. The specifications, for which either annual or weekly subject-matter and name indices are available, can be seen by the public at the Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.2. Both the indices and the specifications are in German. Photographic copies of any specification and drawings may be obtained at the rate of 6d. per page.

A Seven-Day Journal

Radio Aids to Marine Navigation

THE Ministry of Transport announces that the United States Government has organised a second meeting on aids to marine navigation, on similar lines to first international meeting convened by H.M. Government last May. The meeting, to which sixty nations have been invited, will begin in New York City on April 28th, and will end at New London, Connecticut, on May 9, 1947. The United Kingdom delegation will sail in the "Queen Elizabeth" on April 27th. The delegation is composed of representatives of the various interested Government departments, the Lighthouse Authorities, and the shipping and radio industries, and will be led by Sir Robert Watson Watt, with Mr. Denis O'Neill, of the Ministry of Transport, as deputy leader. Other members include Captain J. C. Taylor and Mr. W. Ross, of the Ministry of Transport; Captain R. W. Ravenhill, Director of Navigation; Mr. C. E. Horton, Commander G. V. Parmiter, and Lieut. R. B. Michell, of the Admiralty; Mr. H. Stanesby, of the General Post Office; Captain T. L. Owen, of Trinity House; Colonel B. S. Millard, representing the shipping industry, and Mr. L. H. J. Phillips, representing the radio industry. Captain W. H. Coombs, of the Officers (Merchant Navy) Federation, will accompany the delegation as a special adviser to the Ministry of Transport, while Mr. W. F. Palmer, of the Ministry, will act as secretary to the delegation. Additional representatives of the Government and the shipping industry will join the delegation at New York, as follows: Dr. G. Touch, of the British Supply Office, Washington, representing the Air Ministry and the Ministry of Civil Aviation, with Captain D. F. Robertson, Marine Superintendent of the Cunard White Star Line, New York, and Captain F. O. Madden, Marine Superintendent of T. and J. Brocklebank, Ltd., New York. The British delegation will present a number of papers to the American meeting and will outline the progress made in the United Kingdom since the London meeting. The Government has indicated its willingness to give the fullest co-operation towards ensuring the success of the meeting.

The Retirement of Mr. E. J. Buckton

IT is announced by Messrs. Rendel Palmer and Tritton, consulting and designing chartered civil engineers, of 55, Broadway, Westminster, London, S.W.1, that Mr. E. J. Buckton retired from partnership in the firm on March 31, 1947, and from that date Mr. R. Strick took over the duties of senior partner. Mr. Buckton, who is sixty-three years of age, joined the firm of Rendel Palmer and Tritton as Engineer-in-Charge in 1925 after having had a wide civil engineering experience with the Port of London Authority and also abroad. Four years later he was made a partner in the firm, and for the past ten years he has been the senior partner. Among the many important schemes for which Mr. Buckton was wholly or jointly responsible, we mention the construction of Haifa Harbour, Palestine; the West India Dock, London; The Tilbury new entrance and dry dock, together with the floating landing-stage and the Silvertown Way to the Victoria Dock. Bridge schemes included the demolition of old Waterloo bridge and the construction of the new bridge, and also the reconstruction of Chelsea bridge. Mr. Buckton made his own particular contribution to the problem of housing by the publication in our pages in August and September, 1944, of an interesting series of articles on "Two-Stage Housing." In July, 1945, he further developed his proposals in an article entitled "Extra-Rapid Two-Stage Housing." We are pleased to say that although Mr. Buckton is retiring from the partnership he will continue to maintain active association with the firm, particularly on major works, as one of the firm's consultants. Mr. R. Strick, who is now senior partner, joined the firm in 1937. From 1918 until 1925 he was chief engineer at the Port of Basra, and up to 1937 was bridge engineer with the Bengal Nagpur Railway, India. Since 1937 Mr. Strick has played a leading part in the many schemes carried through by the firm.

Iron and Steel Engineers' Group

IT is announced by the Iron and Steel Institute that arrangements have been made to form an Iron and Steel Engineers' Group within the Institute. An Engineering Committee consisting of members of the iron and steel industry, plant manufacturers, the electrical engineering industry, and the British Iron and Steel Research Association has been set up by the Council to organise the activities of the new group. The Committee is as follows: Chairman, Mr. W. F. Cartwright, of Guest Keen Baldwins Iron and Steel Company, Ltd.; Members, Mr. W. B. Baxter, Appleby Frodingham Steel Company, Ltd.; Mr. W. R. Brown, Ashmore Benson Pease and Co., Ltd.; Mr. H. S. Carnegie, The English Electric Company, Ltd.; Mr. M. Fiennes, Davy and United Engineering Company, Ltd.; Mr. E. T. Judge, Dorman Long and Co., Ltd.; Mr. H. H. Mardon, The British Iron and Steel Research Association, and Mr. I. S. Scott-Maxwell, of Colvilles, Ltd. Ex-Officio Members are Dr. C. H. Desch, F.R.S., President of the Iron and Steel Institute, and The Hon. R. G. Lyttelton, the Honorary Treasurer of the Institute. The Committee will organise meetings and discussions and suitable engineering papers will be published by the Institute, while descriptions of interesting new plant will it is hoped appear in the *Journal* of the Institute. The group will work in close co-operation with the local societies affiliated with the Iron and Steel Institute, and with other British and foreign engineering institutions. It is also announced by the Iron and Steel Institute that from January, 1947, its *Journal* will be issued monthly. In addition to the usual papers it will contain reports issued by the Committees and the staff of the British Iron and Steel Research Association, papers of the Iron and Steel Engineers' Group, reports of discussions, news, abstracts, and book reviews, &c. Bound volumes will also be reissued, containing the contents of the *Journal*, without advertisements, for January to April, May to August, and September to December.

"Enterprise Scotland, 1947"

IT is announced by the Scottish Committee of the Council of Industrial Design that an exhibition of industrial design will be held in Edinburgh in August and September this year and will be styled "Enterprise Scotland, 1947." The Exhibition will take place during the Edinburgh Music Festival and it will open on Monday, August 25th. It will be staged in the Royal Scottish Museum, with supplementary displays in at least twelve of the shop windows in Princes Street. As in the "Britain Can Make It" Exhibition, space will not be sold, the exhibits being chosen from goods submitted to Selection Committees, appointed by the Scottish Committee. Sir Stephen Bilsland is chairman of the Scottish Exhibition Committee. The chief architect will be Mr. Basil Spence, A.R.I.B.A., F.R.I.A.S., and the chief designer Mr. James Gardner, both of whom, we may recall, occupied similar positions in the "Britain Can Make It" Exhibition. The Scottish exhibition will comprise four sections, "Scotland Yesterday," "The Country," "Scotland To-day," and "Scotland To-morrow." In "Scotland To-day" there will be a Shipping Hall, in which will be represented the development of shipbuilding in Scotland from the very first beginnings through all differing phases of ship design, to the present day, which will be typified by a fine model of the Cunard White Star Liner "Queen Elizabeth." Scottish textiles, scientific instruments, tools and examples of printing will also be on view. Mr. M. H. Donaldson is manager of the Exhibition and the Exhibition Committee has representatives of the Department of Health for Scotland, the Lord Provost of Edinburgh, the Central Committee of Scottish Chambers of Commerce, and the Board of Trade.

A New Uranium Factory

IT is announced by the Ministry of Supply that the factory at Springfields, Salwick, near Preston, one of the wartime chemical defence plants, is being converted by the Ministry into an atomic energy centre for the manufacture of uranium metal. The processes to be carried out will consist of the refining of pitchblende concentrates, reduction to metal and the machining and finishing of uranium metal rods, which will be sent elsewhere for insertion in a chain-reacting pile. The Ministry plans to make the working conditions up to, if not better than, the best modern standards for factory working. A fully equipped medical service will be available. The processes will be carried out in buildings in which cleanliness will be of the utmost importance. The grounds will be laid out to conform to the natural beauty of the surrounding district, and there will be none of the unpleasantness usually associated with the chemical works. It is hoped that building work and plant erection will be sufficiently advanced for production to begin in the late autumn. When production reaches its peak, a labour force of over 1000 will be required, of which a number will work on continuous shifts. The industrial labour force, mainly men but with a small number of women in technical and clerical grades, will be recruited locally. It is hoped also to be able to recruit some of the supervisory staff locally, but the problems involved are of such a novel nature that it will be necessary to bring in staff with specialised knowledge. A small number of aluminium bungalows and permanent houses in the Preston area will be built to accommodate the staff which it may be found necessary to recruit from outside the district.

The Government's Planning Staff

IN one of our Journal Notes last week we recorded the appointment of Sir Edwin Plowden as chief planner. Speaking at a press conference last week, Sir Stafford Cripps said that Sir Edwin could be called just a very intelligent temporary Civil Servant, who would help to formulate and implement Government policy, for which Ministers and Ministers alone would be responsible. He would work directly with the Lord President of Council, and Sir Stafford expressed the hope that the Lord President would be back at the end of the month. He went on to say that Sir Edwin's staff would consist, first, of three or four first-class people with experience of planning; secondly of an economist from the economic section of the Cabinet Secretariat, and, thirdly, of people from the departmental planning staffs, who would spend part of their time working at the central planning office. The staff was now being collected and the idea was to make it small but good. Side by side with the planning staff would be a small, highly skilled information section under a chief officer, which would bring together all the ideas and information which the Central Office of Information would disseminate for the purpose of keeping the people in constant touch with the general economic situation. The planning board would work under the chairmanship of Sir Edwin Plowden, and would be tripartite in form and meet regularly. Sir Robert Sinclair, who would bring his great wartime planning experience to bear upon the problems as chief industrial adviser to Sir Edwin, hoped to give one or two days a week to the work. It was hoped to complete all the arrangements outlined before the end of April.

Historic Researches*

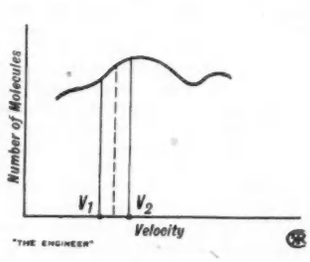
No. XXIII—MOLECULAR PHYSICS

(*Continued from page 279, April 4th*)

James Clerk Maxwell, 1831–1879, was born at Edinburgh. Following private tuition, he entered Edinburgh Academy at the age of ten. At fourteen he gained the mathematical medal and a year later Professor J. D. Forbes described to the Royal Society of Edinburgh a method of drawing ovals—the now familiar string-and-two-pins method—which his young friend James had invented. At sixteen Maxwell entered Edinburgh University and, encouraged by Forbes, probed deeply into topics of current physical interest. While still a student he read before the Royal Society of Edinburgh a paper "On the Equilibrium of Elastic Solids," in which he outlined the principles of optical stress analysis. In 1850 Maxwell, at the strong recommendation of Forbes, went to Cambridge, spending his first term at Peterhouse and then transferring to Trinity College. He graduated as second wrangler in 1854. In 1855 as a fellow of Trinity College he published the first of several papers on colour vision, which later earned him the Royal Society's Rumford medal. In the same year he also published a paper "On Faraday's Lines of Force," in which he gave mathematical expression to Faraday's conception of the mechanism of electro-magnetic induction. In 1856 he was appointed professor of natural philosophy at Marischal College, Aberdeen, a post which he held until 1860, when his chair was suppressed on the amalgamation of Marischal with King's College. During these years he completed a paper "On the Stability of Saturn's Rings," in which he proved that they must consist of disconnected particles. His work on this subject led him to turn his attention to the dynamical theory of gases, on which he presented his first communication to the British Association in 1859. In 1860 he was appointed to the chair of physics and astronomy at King's College, London. He held that post for five years, during which he continued to work on the dynamical theory of gases and evolved his electro-magnetic theory of light. He retired in 1865 to the family estate at Middlebie, Kirkcudbrightshire, and employed his leisure in writing his celebrated "Treatise on Magnetism and Electricity," in the course of which he deduced the existence of electro-magnetic waves—detected experimentally by Hertz twenty years later. In 1871 he emerged from his retirement to become the first occupant of the newly founded chair of experimental physics at Cambridge. As part of his duties it fell to him to supervise the planning of the Cavendish laboratory, which was duly opened in 1874. Maxwell's phenomenal and amazingly fruitful life came to an end on November 5, 1879, in his forty-eighth year. He married the daughter of the Principal of Marischal College, but left no children.

BERNOULLI'S impact theory of gaseous pressure assumes that the molecules of a gas can be treated as if, divided into three equal groups, they moved to and fro with uniform velocity in three directions at right angles to each other. It leads, as we have seen, to the conclusion that the pressure and volume of the gas are related to its mass and the mean molecular velocity by the equation $pV = {}^1/_3 Mv^2$ or $pV = {}^2/_3 E$, where E is the total kinetic energy of the molecules due to their linear velocity. Clausius' extension of the argument does not affect the validity of either of these relationships. It relates solely to the interpretation of the quantity E. Joule took E to represent the entire stock of kinetic energy possessed by the molecules. According to Clausius, it is only a part of the total stock, the other part being that due to the rotation or vibration of the atoms within the molecule. This second part is taken to be always in constant proportion to the first, but it is the first part alone which affects the pressure arising from the impact of the molecules.

The chief feature of Bernoulli's theory which may be thought to be open to criticism is the assumption that all the molecules can be regarded as moving with a uniform mean linear velocity. In actual fact there is no need to make this assumption. The individual molecular velocities undoubtedly cover a wide range. Let us suppose that by some means or other we were able to draw a curve showing the number of molecules possessing particular velocities. We have no idea, at present, what form the curve would assume and will therefore represent it by an irregular line as here :—



Let us now divide the velocity range into a number of consecutive sections, which may be as numerous and as short as we please. Within the sample section indicated on the diagram there will be a definite number of molecules, the velocities of which lie between v_1 and v_2. The shorter the section the more accurate will it be to say that all the molecules covered by it are travelling with a uniform velocity equal to the average velocity for the section, namely, ${}^1/_2 (v_1+v_2)$.

We thus picture the molecules as divided up into a number of groups, the members of each group travelling uniformly with some velocity peculiar to the group. We do not know how many molecules there are in any one group or the group velocity. Without, however, committing ourselves to particular figures in these respects, we can apply Bernoulli's theory to each group of molecules separately and thus find the portion of the total pressure produced by the impact of the molecules composing the group. It is found that the pressure produced by each group is related to the linear kinetic energy of the group in such a way that when we add the results for all the groups the total pressure is related to the total linear kinetic energy of the gas in precisely the same manner as previously, namely, $pV = {}^2/_3 E$.

This process of dividing up the molecules into groups according to their velocities illuminates the nature of the mean velocity v assumed by Bernoulli to be that with which all the molecules are travelling. To avoid prolixity let us consider two bodies of equal mass m travelling with different linear velocities v_A and v_B. The arithmetic mean value of their velocities is ${}^1/_2 (v_A+v_B)$. The sum of their kinetic energies is, however, ${}^1/_2 m (v_A{}^2+v_B{}^2)$. Hence if we assign some imaginary common velocity, v, to them which will be such that if they each possessed it, they would together have the same amount of kinetic energy as they actually have, we must choose v at such a value that $2\times{}^1/_2 mv^2 = {}^1/_2 m (v_A{}^2+v_B{}^2)$. The value of v is thus $\sqrt{{}^1/_2 (v_A{}^2+v_B{}^2)}$. This is not the arithmetic mean value of the two velocities, but the quantity known as the "root mean square." The argument is applicable to any number of particles. Hence, when we use the Bernoulli formula to calculate the "mean velocity" v of the molecules of a gas—for example, 1840 m per second for hydrogen at standard temperature and pressure—the figure we arrive at is not the arithmetic mean of the velocities, but their root mean square. By a well-known proposition the root mean square of any number of quantities is always greater than their arithmetic mean. There is, however, no fixed ratio between them.

The importance of these considerations lies in the fact that certain characteristics of gases which it would be desirable to study in the light of the dynamical theory—for example, their rates of diffusion—depend upon the arithmetic mean value of the molecular velocities and not, like specific heat, upon the root mean square value. It is therefore essential to further progress to discover some method of deducing the arithmetic mean from the root mean square. Here, it would seem we are presented with an impassable barrier. The fundamental knowledge required is the form of the curve in the above diagram or, in plain words, a knowledge of the manner in which the velocities are distributed among the molecules.

To this formidable problem Clerk Maxwell addressed himself in a paper which he read before the Aberdeen meeting of the British Association in 1859. Maxwell pictured the molecules as moving at complete random in all directions with velocities ranging between zero and infinity. At frequent but irregular intervals collisions would occur between them. In the intervals between collisions the molecules would move in rectilinear paths of indefinite lengths with uniform velocities, but, following a collision, each of the two colliding molecules would in general change the direction of its motion and the magnitude of its velocity. In brief, Maxwell postulated that every aspect of the motion of the individual molecules was of a completely random character, the only assumption to be made being that at all times the principle of the conservation of energy was obeyed. Out of this chaos he proceeded to draw law and order.

Maxwell's task really was a double one. He had not only to discover the form of the velocity distribution curve, but to show that it would persist and not vary erratically from instant to instant. In effect he dealt with both these aspects of the subject simultaneously by an application of the theory of probability. To the Victorians, with their fervent belief in natural law, Maxwell's conclusions were little short of staggering. He opened their eyes to the possibility that regularity in physical phenomena did not necessarily imply the existence of "natural law," but might be a mathematical consequence of the operation of pure chance.

With the molecules of a gas ranging in

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* Nos. I, II and III, on "Friction," appeared July 14, 21 and 28, 1944; Nos. IV, V and VI, on "The Mechanical Equivalent of Heat," appeared September 29, October 6 and 13, 1944; Nos. VII, VIII and IX, on "Electro-Dynamics," appeared March 9, 16 and 23, 1945; Nos. X, XI and XII, on "The Ether Drift Experiments," appeared August 3, 10 and 17, 1945; Nos. XIII and XIV, on "Specific, Latent and Atomic Heats," appeared December 7 and 14, 1945; Nos. XV, XVI, XVII and XVIII, on "Chemical Elements and Atoms," appeared August 2, 9, 16 and 23, 1946; Nos. XIX and XX, on "The Classification of the Elements," appeared September 27 and October 4, 1946.

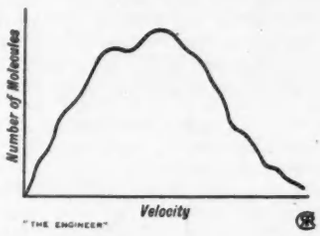
velocity, in a wholly random manner, from zero to infinity, it is not at once obvious how it can be possible to divide them into groups according to their velocities except in a completely arbitrary way. Still less is it obvious why there should be one group which preponderates as regards the number of molecules contained in it over any other group of higher or lower velocity. The shots of a marksman firing at a target will be distributed round the bull's eye, if they are all aimed with equal care, in accordance with the laws of chance. They will cluster round the centre of the bull because the marksman is aiming at that point. Similarly the errors in a number of pieces produced on a lathe and intended to be, say, 1in in diameter will be distributed according to the laws of chance. None of the pieces, if they are all made with equal care, will be greatly oversize or greatly undersize. Their diameters will cluster round 1in because the turner is aiming to produce them to that size. Into both these instances the element of aiming enters. If we divided the shots or pieces into groups according to their position or size, one group embracing the point or size aimed at would preponderate over all the others. What factor corresponding to aiming exists in the case of a large number of molecules moving with random velocities which would justify an expectation of there being a preponderant group with respect to velocity? A little reflection reveals the answer.

It is obviously highly improbable, although not absolutely impossible, that a small number of the molecules can at any instant be moving with very high velocities while the others are stationary or moving very slowly. With such a distribution all or nearly all the kinetic energy of the gas would be concentrated in the few fast-moving molecules. The distribution would be unstable and could not persist for any length of time. Like a few men trying to run through a stationary crowd, the fast-moving molecules would quickly collide with some of the others, thereby losing some of their velocity and imparting it to those with which they collided.

Similarly, it is very improbable, although again not absolutely impossible, that, at any instant, a small number of the molecules can be at rest or moving very slowly while the others are in rapid motion. Like a few men trying to stand still in a surging crowd, the stationary or slow-moving molecules would be subjected to collision by the others and thereby would have their velocity increased.

Thus at both ends a levelling-up process is at work. Very fast-moving molecules are exposed to an action tending to reduce their velocity and very slow-moving molecules to an action tending to increase their velocity. The bulk of the molecules must therefore have velocities which are neither very high nor very low.

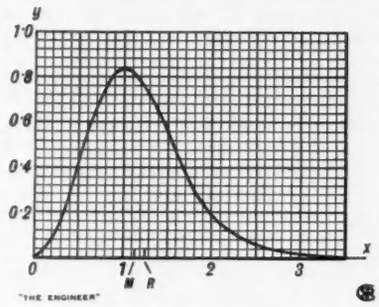
From this broad reasoning there emerges the general form of a curve designed to show the distribution of velocity among the molecules. The form of the curve may flicker somewhat, but if we ignore the flickering or are physically incapable of perceiving it, its general nature will have two outstanding characteristics. It will start at zero, since, by and large, the number of molecules having no velocity must be zero. Secondly, it must return towards zero as it extends to the right, since, by and large, the number of molecules having very high velocities must be substantially zero. From these two characteristics we can deduce a third. Intermediately the curve must rise to at least one maximum value. We can thus amend the form of the curve in the previous diagram in the following way :—



We might make several guesses at the precise nature of the curve. There is, however, one which particularly commends itself to our consideration. It is a curve based on the Gauss-Laplace law of probability and is expressed by the equation

$$y=(4/\sqrt{\pi})\,x^2e^{-x^2}.$$

The form of this curve is depicted herewith. It not only fits the general requirements we have mentioned: it was proved by Maxwell —and this fact must here be taken for granted—that the theory of probability leads directly to it without guesswork of any kind.



MAXWELL'S CURVE OF VELOCITY DISTRIBUTION

Let us examine the curve a little closely. We have described it as a curve showing the distribution of velocities among the molecules. Strictly speaking, however, it is a probability curve, that is to say, its height at any point represents the probability that one molecule picked at random from the mass will have the velocity represented by the chosen point on the horizontal scale. It will be noted that the curve reaches its maximum height at the point marked unity on the horizontal scale. We do not as yet know what velocity, in feet or metres per second, the graduation "unity" represents. Let us, however, call it v_P metres per second. Then the curve implies that if we pick one molecule at random from the mass it is more likely to have this velocity v_P than any other velocity, higher or lower. This must mean that the number of molecules travelling with the velocity v_P is greater than the number travelling with any other velocity. The velocity v_P is known as "the most probable velocity."

The key to the evaluation of the horizontal or velocity scale of the diagram lies in the fact that Bernoulli's theory provides a direct means of calculating the root mean square value of the molecular velocities. That velocity, as we have already seen, is 1840 m per second for hydrogen at standard temperature and pressure. If, therefore, we can fix on the horizontal scale the point corresponding to the root mean square velocity, we will be able to interpret any of the velocity graduations in terms of metres per second. For other gases under the same or different conditions the horizontal scale, in metres per second, will not be the same as for hydrogen. Thus for oxygen at standard temperature and pressure Bernoulli's theory yields 460 m per second as the value of the velocity which we are to identify with the point on the horizontal scale corresponding to the root mean square velocity.

It is not difficult by a purely arithmetical process involving the counting of the squares enclosed by the curve to discover approximately the position of the root mean square value on the horizontal scale. A trial made in this manner has been found to fix the position of the root mean square velocity at a point corresponding to a graduation of 1·27; that is to say, at about the point marked R in the diagram. There is, however, no need to rely on empiricism in this matter. Rigid mathematical analysis is applicable to it and shows that the position of the root mean square velocity is at the graduation corresponding to $\sqrt{1\cdot5}$ or 1·2247. This is therefore the point which for hydrogen at standard temperature and pressure we should mark as representing 1840 m per second. The other graduations on the horizontal scale can be marked proportionately. Thus the unity graduation corresponds to 1500 m per second, which is therefore the value of the "most probable" velocity for hydrogen under the stated conditions.

We have next to discover the position of the arithmetic mean velocity. As we have already noted, it is not the same as the root mean square velocity, and must be less than it. A glance at the curve shows that it is not symmetrical about the ordinate marked unity. The arithmetic mean velocity ordinate should divide the area under the curve into two equal parts. It must therefore lie to the right of the unity graduation, somewhere between the "most probable" and the root mean square velocities. Once again we can arrive at its approximate position by a purely arithmetical process involving the counting of the squares. A trial of this nature has been found to fix the position of the arithmetic mean velocity at a point corresponding to the graduation 1·17. Mathematical analysis shows that its exact position is at a graduation having the value $2/\sqrt{\pi}$ or 1·1284. This point, marked M in the diagram, corresponds in the case of hydrogen at 0 deg. Cent. and 760 mm to an actual velocity of 1695 m per second.

The three velocities which we have now established are thus as follows :—

Hydrogen at 0 Deg. Cent. and 760 mm

	Metres per second.
Most probable velocity (1)	1500
Arithmetic mean velocity (1·1284)	1695
Root mean square velocity (1·2247)... ...	1840

We now turn to the interpretation of the vertical scale of the diagram. It is not scaled to read directly in terms of the number of molecules possessing the velocities marked on the horizontal scale. As we have said before, the vertical ordinates of the curve are probability figures. To interpret these probability figures into numbers of molecules we proceed as follows :—Measure the whole area under the curve (for trial purposes the curve can be taken to end at the ordinate marked "3"; it will be found that this area amounts to about 255 squares). Then the total number of molecules in the gas with which we are dealing will be proportional to this area (or $N=k\,.\,255$, where k is a proportional constant). Next take any pair of ordinates, say, those corresponding to the velocity graduations $^1/_2$ and 2. Measure the area under the curve and bounded by these two ordinates (it will be found to amount to about 218 squares). Then the number of molecules possessing velocities between half and twice the most probable velocity will be propor-

tional to this area (or $n=k \cdot 218$). Dividing the one area by the other we get the proportionate number of molecules having velocities lying between the selected limits ($n/N = 218/255 = 0 \cdot 855$). Hence, out of every one thousand molecules about 855 have velocities lying between half and twice the most probable velocity; that is to say, between 750 m and 3000 m per second in the case of hydrogen at standard temperature and pressure. Drawing the limits closer, we can calculate in the same way that for hydrogen under the stated conditions out of every 1000 molecules:—

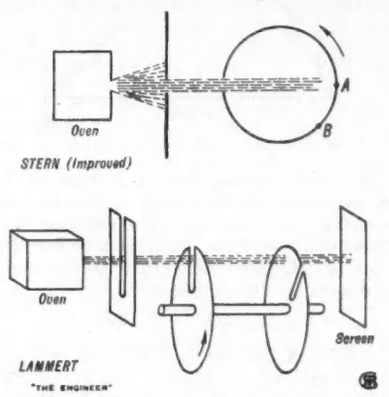
35 have velocities less than 600 m per sec.
211 have velocities between 600 m and 1200 m per sec.
316 have velocities between 1200 m and 1800 m per sec.
249 have velocities between 1800 m and 2400 m per sec.
116 have velocities between 2400 m and 3000 m per sec.
45 have velocities between 3000 m and 3600 m per sec.
17 have velocities between 3600 m and 4200 m per sec.
11 have velocities greater than 4200 m per sec.

These figures relate to hydrogen, the lightest known gas. A similar table can be compiled for any other gas. The difference would lie in the velocity figures, which would be lower in proportion with the higher molecular weight of the gas.

The linear velocities of the molecules even in the case of hydrogen are not immeasurably high. For other gases of higher molecular weight the bulk of them are almost of an "engineering" order. They are, for example, comparable with the blade tip speed of some modern steam turbines, which may safely reach a value of 300 m per second. A further means of appreciating the magnitude of the molecular velocities is provided by comparing them with the velocity of sound. As we might almost guess, the velocity of sound in any gas is not only comparable in value to the mean molecular velocity, but is closely related to it. Thus the velocity of sound in hydrogen at standard temperature and pressure is about 1260 m per second, or, say, 68 per cent of the root mean square of the molecular velocities. In oxygen the velocity of sound at standard temperature and pressure is found to be about 317 m. The root mean square of the molecular velocities for this gas is 460 m per second and therefore the ratio is again 68 per cent. The equality of the ratios is not a mere accident. The dynamical theory of gases requires that there should be a relationship between the two velocities. It asserts that the ratio between them should be equal to $\sqrt{\gamma/3}$, where γ is the ratio of the specific heats. For hydrogen and oxygen γ is approximately 1·4. The theoretical ratio between the two velocities is thus almost exactly 0·68.

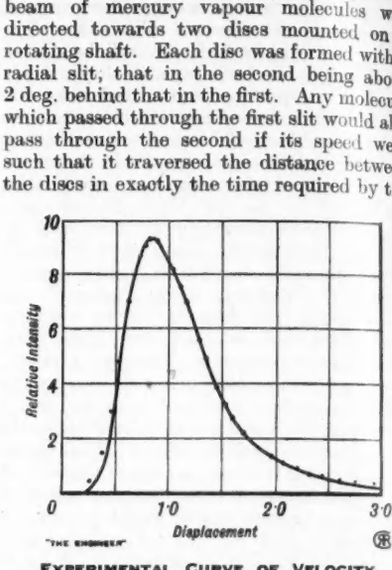
The molecular velocities are thus seen to be well within the scope of laboratory measurement. A number of attempts have been made to determine them by direct experiment and thereby to obtain practical confirmation of the Maxwellian law of distribution. With increasing refinement of method and apparatus these experiments have verified the truth of Maxwell's mathematical results with increasing exactitude.

The experiments have mostly been carried out not with true gases, but with mercury, silver, bismuth, potassium and other metals which can be readily vaporised and which, when received on a suitable surface, leave a deposit. Several investigators have employed a method, the general principle of which was originated in 1920 by Professor Otto Stern, of Frankfort. An improved form of Stern's original apparatus consists of an electrically heated oven, from which molecules of metallic vapour are projected through a slit in a screen, as a parallel beam towards a rotating cylinder in which there is a second slit. The peripheral speed of the cylinder is made a considerable fraction of the mean molecular speed, with the result that the drum turns through a considerable angle during the time taken by a molecule to travel across the interior of the drum. Thus any one molecule reaches the side of the drum, opposite the slit, at some point B displaced from the diametral point A by an amount inversely proportional to the speed of the molecule. In this manner the metallic deposit formed on the inside of the drum presents a spectrum of the molecular velocities. The line of maximum intensity of the deposit corresponds with Maxwell's "most probable velocity" and by analysing the intensity at other points the relative distribution of the velocities can be deduced. The experimental curve obtained in this way in 1931 by Zartman and Ko for bismuth vapour is reproduced herewith. All things considered, and, in particular, the fact that a metallic vapour cannot be regarded as a completely satisfactory substitute for a true gas, the agreement of the experimental curve with Maxwell's law is remarkably good.



EXPERIMENTAL METHOD OF DETERMINING VELOCITY DISTRIBUTION

In 1929 Lammert, following a suggestion by Stern, developed a method whereby those molecules which travelled at any given speed could be picked out from the rest. A parallel beam of mercury vapour molecules was directed towards two discs mounted on a rotating shaft. Each disc was formed with a radial slit, that in the second being about 2 deg. behind that in the first. Any molecule which passed through the first slit would also pass through the second if its speed were such that it traversed the distance between the discs in exactly the time required by the discs to turn through 2 deg. All other molecules of higher or lower speed would fail to pass through the second slit. The molecules which passed through the second slit were received on a screen. The experimental method consisted of running the shaft at different known speeds and comparing the intensities of the screen deposits corresponding to each speed.



EXPERIMENTAL CURVE OF VELOCITY DISTRIBUTION

(To be continued)

The Institution of Naval Architects

No. III—*(Continued from page 291, April 4th)*

THE Annual Dinner of the Institution was held on Wednesday evening, March 26th. The chief guest was Mr. Winston Churchill.

The president, Lord Chatfield, proposing the toast of "Our Guest of Honour, our new Honorary Member, Mr. Churchill," said that during his wonderful career, in the course of which he had occupied every important post in the State, Mr. Churchill had been twice First Lord of the Admiralty, in the crucial opening months of two world wars. When he had first taken the helm of the Admiralty ship he had found a wonderful fleet under his hands, a fleet which at that time had been untested for a hundred years, a fleet which had completely altered in that time to something which could not have been conceived of by our forefathers. Our naval architects of that day had led the world in originality of design and originality of type of warship, from the first armoured ship in 1860 to the Dreadnought, the battle cruiser, to later when Sir Eustace d'Eyncourt was Director of Naval Construction, and we had placed on the seas the first aircraft carrier that had ever floated.

In the second world war Mr. Churchill had again found himself at the helm of the Admiralty ship. How different was the situation that he faced then! The terrible London Naval Treaty which had hamstrung the Admiralty, the naval architects and the shipbuilders, and which had been determined only in 1937, had left the fleet a shadow of its old self. He had found the old ships of the Queen Elizabeth class, twenty-five years later, still the main part of our no longer grand fleet. Certainly he had found a large building programme under way, a programme he had had to stimulate and encourage, but the ships could not be completed until two years after the war had started.

Lord Chatfield said that the Navy would never be an obsolete service. We should always want ships and sailors to man them, so long as we carried our food and our supplies in ships—and even Sir Frederick Handley Page (who was present at the dinner) would agree that that would be so for some years yet—so long should we require ships to protect the traffic on the oceans in all weathers, by day and by night, against attack by enemy warships. He believed that in this atomic age, if we ever had another war—which God forbid—the sea would be the safest place.

Mr. Churchill, in his response, said that in 1939, at the outbreak of war, he had inherited the fleet for which Lord Chatfield, as First Sea Lord, had been largely responsible, and he assured his hearers that the fleet at the disposal of the Lords Commissioners of the Admiralty on September 3, 1939, was not only equal to all the tests and trials which could immediately be put

upon it. It had within it the necessary reserves to enable the new developments and the surprises which every war brought about to be met as they arose, in good time, so that we retained not only the command of the seas as expressed by the readiness to undertake a general naval action at any time, but also the power to transport across the threatened oceans all that vast commerce upon which our life and our war-making capacity depended. In many ways we were unprepared before the second world war, but it could not be said in any circumstances that the Navy had not at its disposal ample forces to be able to deal with the emergency. For that fact Lord Chatfield and others of his friends who were present on that occasion were entitled to long personal satisfaction and wide public appreciation.

It had been a great satisfaction to him, and an odd sensation, to return to the Admiralty in 1939, to find that all the battleships they had were the same old friends which Sir Philip Watts had designed, to which Lord Fisher had given some thought, and for which he had obtained the money from Parliament more than a quarter of a century before. And when Lord Chatfield could not get a new battleship out of the pre-war Cabinet he had resorted to the well-known naval expedient of building a new cask around the old bunghole! He had been a severe and constant critic of the Government before the war in regard to all the preparations for war; but when he went to the Admiralty he had had no cause to complain that we had not the tools for the job and the tools to make the new ones.

As to the future, and recalling Lord Chatfield's reference to the atomic age, he said the means of destroying aircraft might well keep pace with the deadliness of the explosives which aircraft could carry. Therefore, it was foolish for people who had not given long thought to those matters just to dismiss, as though they would no longer play a part in future wars, the surface warships which steamed across the oceans. Once we admitted that surface warships would still steam across the oceans—and among warships he included aircraft carriers—we were driven to the inevitable logic that those guardian carriers must be protected, step by step, from the attack of other surface ships, until, finally, something differently shaped—he would not give the secret away, but at any rate, it might be called an inexpungeable naval vessel—was found to give sanction to the whole operations which proceeded around a battleship or a battle fleet.

Sir Maurice E. Denny, replying to the toast of "The Institution," said that it was necessary that there should be a sufficient number of building yards and a sufficient number of engine works. Two great wars had shown us how vital it was that our maritime forces should be expanded rapidly and effectively during hostilities. In peace it could hardly be expected that the nation should maintain a Navy adequate in number of ships and in personnel to any emergency that could be imagined. There were limits to the calls that could be made on the taxpayer; but on the outbreak of war, as we had seen twice, there were no bounds to the demand to replace losses and to expand the fighting forces. There were limits, however, to quick expansion, and those were set both by the number of constructing establishments and by the number of skilled men following the trades of shipbuilding and marine engineering. It followed that this country could not safely allow the industry to contract too far. Through volume of output it was vital that it should continually be in a position to maintain a vigorous life. It was probable that the industry was now too large for average requirements. Who would say that in the not distant future it might not have shrunk to a point at which it was too small for national security? By merchant building alone it seemed doubtful whether an adequate number and diversity of establishments could be maintained. There must also be a flow of Naval work, preferably regulated in volume in inverse ratio to the volume of merchant work. Unless that could be brought about, and unless a sufficient number of firms could be kept in close touch with Naval requirements and standards, it was at least permissible to doubt whether the third time would also be lucky.

On Thursday morning, March 27th, the first paper presented was "Classification Standards and Longitudinal Strength," by Mr. J. L. Adam.

Discussion

Mr. R. B. Shepherd said the author had focused attention on the great advances in structural efficiency and changes in ship design during the last fifty years. It was now a far cry from the earlier days of steel ships, when a fully plated second deck was considered essential for transverse strength, the weather deck being of wood with light stringers and ties only. The redistribution of material and plating over weather decks, with the elimination of wood sheathing, drew attention to the necessity for adequate compressive strength, particularly in ballast conditions where large deep tanks and bunker spaces were concentrated amidships. The three-island tramp, typical twenty-five years ago, had now given place to the complete superstructure type with a resultant increase in hogging moment of some 10 per cent in the loaded condition. Ballast dispositions now adopted in some bulk cargo ships might also result in considerable hogging stresses. These and many other factors must be taken into consideration in the trend towards further redistribution of material in the topsides, and the consequent effects on the hull girder as a whole. The author had made quite clear that the section modulus, as a basis for assessment of longitudinal strength, must be applied with caution and experience, and as a comparative standard only. While relatively simple hull girders, such as single-deck tankers, had been found to behave in vertical bending under still water conditions generally in accordance with beam theory, we still awaited experimental results on the more complex structures of cargo ships having double bottoms and more than one deck. But static conditions did not represent those which ships experienced at sea, and which included the effects of impulse loading, torsion and bending in the horizontal as well as vertical planes, with the hull structure subjected to complex motions. The results of the protracted observations on the "Ocean Vulcan" under North Atlantic conditions, with the associated still water tests now being carried out, would therefore be of the greatest value, as would all work of a similar nature. He therefore endorsed the author's remarks on the load line standard as a criterion of longitudinal sufficiency, and the recognition of its limitations.

Whilst he would not quarrel with the author's general thesis that some additional area at the top flange of the hull girder was desirable for the range of types illustrated in the paper, he offered the following comments. Satisfactory behaviour, particularly of decks, was largely dependent on the treatment of structural discontinuities. Longitudinal girders were of great value in this respect, and for resisting main compressive stresses in plating panels, but he suggested to the author that where additional tensile material was required an increase in deck thickness was a simpler and more effective arrangement.

He had possibly misunderstood the argument that, within certain limits, the area of lower decks did not matter, but he was doubtful whether the best method of compensating for insufficient thickness of a second deck was to increase that of the strength deck. There was no proof of this in the instance quoted of second decks 0·28in thick, where the buckling was actually cured by fitting intercostal girders to that deck—not to the strength deck. Nevertheless, experience had generally enabled us to determine the necessary minima for such decks. He further emphasised, in disposing the material at the topsides, the importance of ensuring that the sheerstrake was adequate in relation to the deck thickness, and to the proportions of the hull girder.

As regards welding, the experience of Lloyd's Register fully confirmed the absence of structural tensile failure through lines of rivet holes. Here was an outstanding instance of experience being at variance with existing theory. This most important fact, however, was frequently not appreciated by designers. The absence of overlapped longitudinal seams undoubtedly deprived welded plating of some stiffness in compression. The precise evaluation of this loss we were not yet able to assess, but it was influenced by the relation between the width of strakes and the frame spacing. He was personally impressed with the advantage of a longitudinal system of framing at the bottom and strength decks, at least in the 'midship portion of welded structures. At the same time, he agreed with the author that reduction in plating thickness, where associated with longitudinal support, must, at the present stage of our experimental knowledge and experience, be limited in extent.

He congratulated the author on the method he had developed for tabulation of shell and deck scantlings. This marked a definite stage in progress and should prove practicable in everyday use. In Lloyd's Register they had for some time been working on another method of presentation, simple of operation and clearly indicating the effects of differences in dimensions and draught, which quite naturally they felt would be even better. Whilst a little rivalry in this direction was wholesome, the great and constant responsibility of the classification societies permitted of no competition in standards of structural strength. He was therefore happy to state that proposals of the technical staff of Lloyd's Register, now reaching their culminating stages, represented requirements for longitudinal strength which were closely comparable to those given in the paper.

Mr. J. Turnbull said that the most important point to which the paper drew attention was the fact that the classification societies had considered it necessary to increase the standard of longitudinal strength, owing to unsatisfactory experience. It was remarkable, too, that the so-called unsatisfactory ship was only a little below the standard of what had been found in the satisfactory ship. The classification societies were naturally anxious not to be forever asking the shipowner to fit heavier plates than were necessary, and the fact that the difference between

the unsatisfactory and the satisfactory ship rather indicated that the standard theory was correct with the present conditions.

Dr. Livingstone Smith remarked that throughout the paper stress was laid on the importance of deflection in the ship girder. In other words, considerations of strength must be allied with practical considerations of stiffness, and the remarks on the apportionment of material as between the upper and lower flanges of the girder were most interesting. Was it quite impossible to estimate the buckling stresses appropriate to transverse-stiffened decks? If these buckling stresses were not easily calculable, then obviously there was a sad dearth of practical information which we should take steps to remedy.

Sir Archibald Denny said the paper was really the result of a very large number of experiments in the best and largest laboratory of the world, *viz.*, at sea in service, and any shipowner reading the paper must feel satisfied that he was being given very good instruments indeed with which to carry on his trade. Mr. Turnbull had mentioned the small amount of additional material required to convert an unsatisfactory ship into a satisfactory ship—a matter of a few tons. If that were so, then it was quite clear that the ships which the builders were delivering to the owners did not suffer from excess material. To that extent, therefore, they were not unduly costly and the owner did not have to carry about weight which he would rather have in the holds. That was a most interesting fact.

Mr. Adam replied shortly.

The next paper presented was "Limits of Torsional Vibration Stress in Marine Oil Engine Shafting," by Dr. S. F. Dorey. Owing to the absence of Dr. Dorey, the paper was introduced by Mr. Archer on his behalf. A summary of the paper is printed on page 310 of this issue.

Discussion

Mr. C. C. Pounder said that Dr. Dorey had gone to considerable trouble to assess the exact limits of torsional vibration stress that shafts would stand, but risk of failure was not the limiting factor. Vibrations of amplitudes too small to cause dangerous stresses in the shaft might still be large enough to make an engine run roughly or even to cause damage to such engine parts as gear wheel drives. For main propelling machinery he agreed that 16 per cent above the service revolutions was a reasonable margin to allow for racing, and a somewhat larger margin below service revolutions should, of course, also be kept clear of critical speeds. In the case of generator engines, which were for all practical purposes constant-speed machines, he thought the margin of 10 per cent above and below service revolutions, proposed by Lloyd's to be regarded as the range for continuous operation, was too wide, and they did not seem to have taken into consideration the fact that the speed of these machines could be controlled within limits by adjusting the governor springs.

In many engines critical speeds below the service range of revolutions were unavoidable, *e.g.*, in six-cylinder four-cycle engines up to 2500 s.h.p., installed amidships in small and medium-size vessels. If the limits of stress now proposed by Dr. Dorey had been in force earlier, it was probable that in nearly all installations of this type built during the last fifteen or twenty years, *i.e.*, since the practice of fitting fly-wheels was abandoned, Lloyd's would have enforced the marking of a prohibited speed range on the tachometers. Yet these vessels had proved fully satisfactory in service. Prohibited ranges were unsatisfactory both to owner and builder, and he personally would be reluctant to agree to marking a tachometer in this way unless the necessity for it could be clearly demonstrated. To try and assess the exact stress that shafting would stand, by means of fatigue experiments or otherwise, was too theoretical a manner of approach to the subject. A more trustworthy guide would be analysis of previous good practice. If this were done, it would be found that many vessels which had given good service without any markings on the tachometer had criticals at low revolutions in excess of the limits now proposed.

There was little justification for discriminating between intermediate and thrust shafts, to the disadvantage of the latter, when Lloyd's admitted that they had been practically immune from failures. It seemed to be another instance in which Lloyd's had put theory before practice. If the torque was transmitted through the collar—as in a coupling flange—the fillets would no doubt act as stress raisers, but as the collar, as far as torque was concerned, was merely an unstressed excrescence, one would reasonably expect the fillets to have little effect. Similar considerations applied to generator engines. Analysis of previous good practice would supply a more trustworthy guide to what criticals could be safely run through in starting than any theoretical considerations of shaft stress.

Dr. S. Livingston Smith congratulated the author on tackling the very difficult and important problem of the fatigue strength of full-sized shafts, because until recently most of our knowledge of the intrinsic fatigue strength of materials had been based on laboratory tests on specimens of from 0·3in to 0·5in diameter, although it was fair to say that within this limitation this knowledge was very extensive. Engineers had, however, always been very cautious in applying the results of these small-scale tests to large components, and the figures quoted in the paper fully justified their attitude. It appeared that scale effect, or whatever it might be called, could be very great. Take, for instance, the figures in the early part of the paper. The author's tests indicated that the reversed torsion fatigue limit for a 10in diameter solid-forged mild steel shaft of 28–32 tons quality might be taken as ±8300 lb per square inch, or 3·7 tons per square inch. The fatigue limit for a 0·3in polished specimen of 27·5 tons per square inch steel was about 10 tons per square inch, which indicated a scale factor of $10/3{\cdot}7=2{\cdot}7$, or $11/3{\cdot}7=3$. That was very interesting and, at the same time, disturbing, because it raised the question of the real value to engineers dealing with large components of the enormous amount of data on fatigue built on the results obtained with laboratory size specimens. The proposals in the paper represented a very timely and praiseworthy attempt to put the design of oil engine crankshafts on a rational basis, but he was sure the author would be the first to say that they represented an interim measure which would need to be revised in the light of subsequent experimental data, since it was abundantly clear that there were many gaps in our knowledge of the permissible vibration stresses. Lloyd's Register was about to carry out, for the British Shipbuilding Research Association, an extensive series of large-scale torsional fatigue tests, and the results of those should go far to fill some of those gaps.

Mr. Archer, indicating that Dr. Dorey would give a detailed reply in writing, dealt with a few points. If one could be absolutely certain that the engineers on board all classes of vessels were fully aware of the possible dangers of serious criticals, there would be some force in Mr. Pounder's suggestion, but the classification societies had to deal with all classes of vessels, and although in the higher-class ships the engineers might be more fully aware of these factors—and the necessity for marking critical ranges might not appear so immediately important—account must be taken of the wider scope for which the classification societies had to cater. He wished to make it clear that the proposals in the paper were not intended to be in any way final recommendations. The purpose was to elicit the views of industry, to analyse them in the light of experience and finally to attempt to come to some agreement as to what should constitute maximum permissible stresses. As to the scale effect and the factor of 3:1 mentioned by Dr. Livingston Smith, it should be borne in mind that scale effect was not the only factor which came into consideration, since there was very considerable stress concentration. Nevertheless, it was appreciated there was still a large field for experimental work in this connection.

(To be continued)

Conversion of Canadian Locomotives

In the Angus shops of the Canadian Pacific Railway in Montreal, a number of the company's old "3600" and "3700" series locomotives has been converted to the new "5200" series.

The "N2" class locomotives in the "3600" and "3700" series had frames, cylinders, motion, wheels, &c., practically identical with the "5100" series "P1" class locomotives, with the exception that the latter class had a trailing truck. For the conversion it has been relatively simple to cut the main frames at the centre of the pedestal of the rear driving wheels and weld on a new section of frame, similar to that of the "P1" locomotives. To this has been attached a new trailing truck of the same general design as that used on the "5100" engines and many other locomotives of the company.

The trailing truck has been added to the "N2" class in order to fit it with a new boiler, with a working pressure of 215 lb per square inch, and a stoker, as was done on the "5100" series locomotives a few years ago. The application of a stoker to the "N2" class, as originally built, was impracticable for various reasons.

To utilise the higher boiler pressure it has been necessary to reduce the cylinder diameters from 23in to 22in by bushing.

The original "N2" class locomotives had small tenders with a capacity of 5000 gallons of water and 12 tons of coal. New tenders have been built with a capacity of 10,000 gallons of water and 18 tons of coal.

The "N2" class locomotives were built between the years 1909 and 1914, and during the 'twenties both they and "P1" class locomotives were given new cylinders, frames, motion and superheaters, so that in the recent conversions the company had good material upon which to work.

The engines in the "5100" series were considered exceptionally good from the operating and maintenance aspects and for their general performance. They have been mostly in service on secondary lines, where bridges, &c., will not permit the operation of heavier locomotives. The company still has on its extensive system many sections where comparatively small locomotives, such as these, will give excellent service for years to come and fully justify the conversion programme. This work has given the company a locomotive at least the equal of, if not better than, the present "P1" class, and one which has good riding qualities, satisfactory to the operating crews.

Side-Blown Converter Practice

ON March 20th, the second day of the joint meeting of the Iron and Steel Institute and the British Iron and Steel Research Association, held at 4, Grosvenor Gardens, London, side-blown converter practice was discussed. Members of the Institute of British Foundrymen were invited and took part in the discussion. The chair was taken by Mr. F. Cousans, and at the morning session, the First Report of the Converter Refractories Sub-Committee of the British Iron and Steel Research Association was presented.

The Chairman, opening the meeting, stated that during the recent war operators of side-blown converter steel plants were faced with many problems arising from the necessity of reducing to a minimum the use of hematite pig iron. The country was, at one period, in a very difficult position as regards supplies of hematite pig iron, and accordingly efforts were made by the Iron and Steel Control to assist steel founders with their side-blown converter practice by the provision of plant and technical knowledge.

Many of the converter foundries operating on cupola melted metal found that their cupola installations were of very old design, and gave metal of low total carbon content, so that when asked to use up to 80 per cent steel scrap in their cupola charge, they found themselves in a very difficult position in obtaining a satisfactory temperature increment during the subsequent conversion process. Remarkable results were obtained at the Stantongate Ironworks during the war, in which cupola melted metal of low silicon content was superheated in pulverised coal-fired furnaces, and finally converted in side-blown Bessemer converters. Steel made in this manner possessed excellent fluidity, and gave excellent physical properties after proper heat treatment.

Three or four firms during the war had been carrying out research work on their Bessemer steel, and the Control suggested that they pooled their knowledge to make it available for all converter users. A committe was formed in 1943 under Dr. T. P. Colclough for that purpose. Apart from the actual operating details, the Committee realised that it would have to give consideration to the plant and refractories side, so the Refractories Panel was formed under the Chairmanship of Professor Sarjant—then of Hadfield's—with the assistance of representatives from the larger steel producing firms possessing research laboratories, together with other refractory technologists. The panel had done a valuable piece of work.

Refractories Sub-Committee Report

Professor Sarjant, in introducing the report pointed out that the Converter Refractories Sub-Committee first reviewed current practice. The essentials were set out in two tables in the report, and were separated out into three main groups according to capacity. That information formed a useful background on which to build the experimental investigations in the Committee's programme. It pointed to the need for exploring the relative values of monolithic and brick linings, and a start had been made on a study of the properties of those materials.

Part II of the report dealt with the examination of typical materials and details were given concerning chemical composition, grading, refractories, behaviour in firing, and an X-ray examination of two of the materials. The results of that work led to a tentative expression of the desirable properties which should be looked for in a monolithic material, as well as indicating the importance of operational factors in controlling refractory consumption.

The replies to a questionnaire showed the existence of widely varying conditions in shop practice throughout the whole thermal history of the converter lining. Accordingly, experimental work comprising a series of carefully conducted observations was undertaken in three different plants with the object of exploring the whole thermal history of the material of the lining from the drying stage to the sequential blowing of the charges. At the same time, the changes of the chemical and physical characteristics of the material of the lining were examined.

The Report contained a series of conclusions based on the results of the experimental work with brick-lined vessels. A study of monolithic linings formed part of the future programme of the panel.

The Report is summarised as follows :—

First Report of the Refractories Sub-Committee

The outstanding points of each section of the report are the large variables in the industry regarding the nature and methods of the use of refractories. The very high consumption of refractories noted in certain cases is obviously capable of improvement. There are certain anomalies in the characteristics of some monolithic linings which are being used with a measure of success. These facts alone focus attention on the necessity for further work in order to enable recommendations to be more specific with regard to the best materials and technique to be used.

It is considered that operational factors have played a large part in deciding the performance of materials, and have made it impossible to correlate fully such performance with laboratory data. Any further work must be on a more comparable basis than exists in the various plants from which data have been obtained, and the first recommendation is that plant should be available for use in future experimental work. The investigations have made available a certain amount of information which is put forward as a basis for discussion :

(*a*) Large vessels are more economical in consumption of refractories than small ones.

(*b*) Current practice relates the size of the converter to the production of the steel required per day being available from about fifteen heats.

(*c*) Monolithic linings are preferred for small vessels, with a gradual change over to silica brick for the largest vessels.

(*d*) It has been established that improvement in lining life follows the use of sand charged into the converter before the metal. This applies particularly to plants using low silicon iron.

(*e*) The silica content of monolithic lining materials should be over 90 per cent, and the clay constituent should be sufficiently fine to develop adequate plasticity when present in relatively small amounts.

(*f*) The bricks used for converter linings are generally of the type used in open hearth furnace roofs, although a special high iron oxide type with improved thermal shock resistance is specially manufactured for converters. The samples examined had a wide range of specific gravity and therefore will require varying degrees of control on heating up.

(*g*) The relative merits of monolithic and brick linings can only be assessed by carefully controlled experiments in the same plant. Experiments on these lines are visualised in the future programme of the Panel.

Discussion

Dr. J. White (Sheffield University) said the University was involved in a continuation of this work and the question was "Where do we go from here?" He urged that detailed consideration should be given to the questions of grading linings and their chemical composition. The Committee had been greatly impressed by the wide differences in the monolithic type of lining.

Dr. C. R. Rigby (British Refractories Research Association) said the results of the petrological work contained in the Report indicated the close similarity between the behaviour of the bricks in the converter and the bricks in open hearth roofs. At the same time, although there was a series of clearly defined zones in both cases, there was a considerable difference in their occurrence which indicated that the temperature gradient was very much steeper in the case of the converter than in the case of the open hearth furnace. Great importance attached to the temperature gradient inside the various zones and in this might be found an explanation of the fact that apparently inferior bricks sometimes gave very good lives.

There was no time for further discussion, and the meeting adjourned until the afternoon.

Side-Blown Converter Practice Sub-Committee Report

Dr. T. P. Colclough, introducing the report, said the work described had its origin in the efforts of Mr. Paul Fassotte, the Technical Adviser to the Steel Castings Division of the Iron and Steel Control, to secure improvements in the steel production of foundries during the war.

The work consisted, in the first place, of a survey of the converters in current use, and that survey showed there was no standardisation of either design or shape of the operating chamber, or even of the fundamentals. It was found, for instance, that the ratio of bath area to capacity varied by 60 per cent; that of the bath area to the depth of well by over 300 per cent, and there was no uniformity of tuyeres in size or number, and although the process was one of interaction of air and metal the ratio of tuyere area to volume of metal blown varied by over 50 per cent. Clearly, therefore, there was a demand for the plant engineering division and technical operators to get together and formulate the optimum shape and dimensions of the vessel.

Data were then collected on average operating conditions, and typical heats from four representative firms were studied in detail. Here again, although the process had been in use for about ninety years, there was wide divergence in the quality of metal and its temperature and in the operations. For example, the metal varied in carbon from 2·5 to 3·3 per cent, and in silicon from 0·35 to 1·9 per cent. The temperature of the metal ranged from 1300 deg. to 1450 deg. C. In operation, the wind blown ranged from 450 to 1100 cubic feet per minute per ton of metal, and the blowing time from twenty-nine minutes to eleven minutes per charge. The metal loss in blowing was divided into two sections—the chemical loss varied only from 3·7 to 4·7 per cent due to variations in chemical analysis, but the mechanical loss due to injection and vaporisation ranged from 6·2 to 11·6 per cent. These factors had a profound effect on the economics of the process, and here again the time was ripe for standardisation on the most economic basis.

Attention was then directed to the details of the process by intensive study of the individual heats. These studies confirmed the accepted views as to the relative oxidation of carbon, silicon and manganese. It would appear from the experiments carried out that there was a critical temperature for the oxidation of carbon, and that the prime function of the silicon was to provide the

heat required for this rise in temperature. That focussed the problem raised in Fassotte's paper as to whether the minimum initial temperature should be provided by silicon, or by external heating with the resulting economies in silicon, shorter blowing time, increased production and lower metal losses.

The tests showed a marked difference between the side-blown and bottom-blown converters. In the latter, the reaction was essentially one between the air and metal, and the gas evolved consisted of CO and N_2, which pass through the body of the metal. In the side-blown converter, however, the first stage consisted of the oxidation of Fe and Si, which rapidly formed a ferrous silicate slag, and further oxidation was effected by the slag-metal reaction as in the open hearth process. Further, practically the whole of the CO gas formed from the carbon oxidation was immediately burned to CO_2 inside the vessel and imparted heat to the metal, giving a higher thermal efficiency.

A further important feature revealed by the investigation was the gas content of the blown metal. Steel founders had always maintained a high standard of quality in the product made by the side-blown converter process, and the tests had demonstrated that the oxygen content of that metal was of the same order as open hearth steel, and that the nitrogen content, while higher than that of open hearth steel, was of the same order as electric furnace steel and only about one half that of the ordinary bottom-blown converter steel.

Discussion

Lieut.-Col. T. B. Biernacki (Polish Technical Institute) said the report was the first successful attempt to widen our knowledge about the side-blown converter, which was very limited indeed. The converter process had been neglected by metallurgists all over the world for many years, and they had found better tools for making steel in the open hearth and electric furnace. But during the war in the U.S.A., and to some extent in this country, the side-blown converter production of steel castings showed an upward trend. In the U.S.A., in 1933, there were twelve steel foundries using the side-blown converter process, employing seventeen converters. In January, 1944, there were thirty-seven foundries operating sixty-six converters. The main factors contributing to the revived use of the converter, apart from the high demand for steel during the war, were improved and successful methods of desulphurisation and dephosphorisation of cupola metal, development of a triplexing method using cupola-converter-electric furnace combination which permitted continuous supply of molten metal to the moulds, and improved methods of control of the converter blow. The lower installation costs of the side-blown converter plant in comparison with any other steel-making unit of equal capacity, were also responsible for this revival.

The main conclusion of the report was that the side-blown converter process appeared to be predominantly one of metal-slag reaction, and not one of metal-air reaction, as in the Bessemer process. Consequently, there should be much more similarity between the side-blown converter process and the acid open hearth process, than between the side-blown converter process and the Bessemer process. The report gave two similarities to support this, but whilst he did not question the report in this respect, he felt there were good reasons for believing there was quite good similarity also between the side-blown converter process and the Bessemer process.

Mr. P. C. Fassotte said the most important point in the report was the attention which had been drawn to the importance of total silicon content in the metal to be blown, and he did not think it was an exaggeration to say that the whole economics of the side-blown converter process hinged around this question of the total silicon content, irrespective of the time when the silicon was introduced, or the form in which the metallic silicon was introduced. In his view, the implications of the report were more far-reaching than appeared at first sight, and the builders of new steel plants would have to take cognisance of the report. It was now possible to visualise steel melting plants producing much larger quantities of steel per hour, and with intervals between the heats of as low as five minutes. The problem of blast required further investigation and there was every possibility of enriching the blast by the introduction of oxygen. It was satisfactory to see from the report that attention was to be given to that. There was also the question of revealing the full extent to which the converter process lent itself to the production of light alloy steels.

Mr. J. L. Harrison (Catton and Co., Ltd.), said it was rather unfortunate that the report dealt with only one heat which took fifty minutes to blow. That was rather contrary to normal practice, where the time was about twenty minutes, and he suggested that in future work a large number of results should be taken and the averages studied. The whole thing should be studied on a statistical basis rather than on the basis of individual heats. He had been concerned with work on these lines and found the results much more reliable.

Mr. H. O. Howson criticised the fundamental results in the report and, remarking that there was a lack of practical observations on the process, said that practical observation was essential to any scientific approach to that problem. The operation was definitely more complex than was indicated in the report, and he considered that the idea of a slag-metal reaction was quite out of place in side-blown converter practice.

Dr. W. C. Newell (British Iron and Steel Research Association) said he had no doubt that first class quality steel could be, and was, made in side-blown converters but, in the past, there had been considerable prejudice, due to lack of sufficient control of the process. One of the bogies raised about it was the gas content of the steel produced, and it would have improved the value of the report if figures had been given of the actual hydrogen and nitrogen content of the samples analysed.

Dr. Colclough said that these figures had been published years ago by Fassotte and there was no point in repeating them. It was assumed they were well known. Commenting on what Lieut.-Col. Biernacki had said, he pointed out that the Committee was trying to emphasise the difference between the bottom-blown and the side-blown converter. In the bottom-blown converter, the whole of the reaction practically must be between the air and the metal, although there was some reaction between the slag and the metal. He suggested, however, that 90 per cent was air-metal reaction and 10 per cent slag-metal reaction. On the other hand, in the case of the side-blown converter, the whole of the reaction was between air and metal because there was no slag. If it were not an air-metal reaction, the reaction would never start at all. One of the fundamental difficulties of converter practice to-day, was that it was not possible to measure the air going in. We had no idea what it was, and we had no idea what the losses were. Therefore, he regarded it as essential that an experimental converter should be built with all possible gadgets on it in order to get the information that was so necessary.

The Chairman, bringing the meeting to a close, said the Melting Committee and the Refractories Sub-Committee would shortly be having a joint meeting, and he promised that consideration would be given to the discussion, and the suggestion that their future programme of research should include a continuation of the work already done.

The French National Electricity Service

The organisation of "Electricité de France," the French nationalised electricity service, differs somewhat from that of other public utilities, the aim being greater flexibility, characterised by certain similarities to ordinary commercial and industrial management.

Until the definite structure of the nationalised company can be laid down, the temporary organisation takes in 16 hydro-electric producing areas, 9 thermal production regions, 8 regional centres for "mouvements d'energie," 8 regional transport centres, and 14 equipment regions. Of the latter, 9 are concerned with hydro-electric equipment, 4 with thermal equipment, and 1 with transport.

General management of the industry will be by "Electricité de France," which will be charged with studying, creating and exploiting electricity. "Services de Distribution" for the different geographic areas will be responsible for distribution, under the authority of administrative committees set up by "Electricité de France," and composed of representatives of the State, consumers and personnel.

The national service (Electricité de France) administrative committee comprises six state representatives designated by the competent ministries; six consumers' representatives, of whom four are delegated by the local distributing organisations, one by the principal industrial consumers, and one by agricultural associations; and six representatives of personnel. "Services de Distribution" comprises four members representing the National Service, six representing the different personnel categories, and three representing consumers.

The national service is headed by a director-general chosen by the cabinet. Directors of the distribution services are appointed by the administrative committees of the services, with the approval of the national service.

The Ministry of Finance appoints commissioners to control the national service, and reports are published in the French "Hansard." Local services' reports are published in local law papers. Legal provision has been provided for an auditing body which examines the accounts and reports made by the administrative committees on the accounts. Administrators are held responsible in much the same way as if working for a limited company. They can be recalled at any time for mismanagement and their policy may be questioned in Parliament.

It is contended that the nationalisation of electricity in France is less an expropriation than the reorganisation of an important public service. The industrial and commercial type of organisation has been retained because financial autonomy and technical independence is held to be important. The usual commercial and industrial rules prevail, the organisation being subject to taxes and responsible for expenses and investments. But the closer connection of workers with the management is hoped to prove advantageous to the nation.

The Physical Society's Exhibition

No. I

THIS week the Physical Society is holding its 31st annual exhibition of scientific instruments and apparatus at the Imperial College, Imperial Institute Road, South Kensington. The exhibition opened on April 9th, and will remain open daily from 10 a.m. to 1 p.m., and from 2 p.m. to 9 p.m., until to-morrow, Saturday, April 12th. By holding the exhibition this year in April instead of in January, as in the past, it is hoped that the prospect of less inclement weather, coupled with longer hours of daylight, will appeal to prospective visitors from the provinces and further afield.

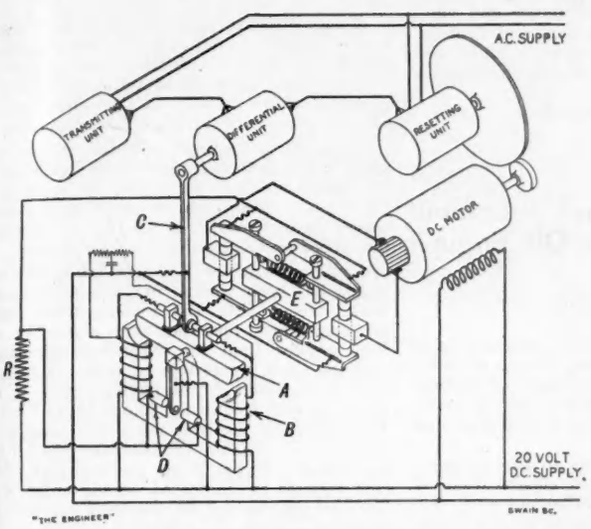


FIG. 1—VIBRATING RELAY FOR PROPORTIONAL CURRENT CONTROL—EVERSHED AND VIGNOLES

In size and scope the current exhibition maintains the new standard set up in the first post-war exhibition of 1946; the number of exhibitors in the trade section has increased from 112 to 118, while the research and educational section has declined in numerical strength from thirty-five to twenty-nine. A significant change is, however, marked by the greatly increased support from Service and Departmental research organisations. Newcomers occupying stands in the research and educational section include the Admiralty Experimental Establishments, the Atomic Energy Research Establishment (Harwell), the Post Office Engineering Department (Stone, Staffs), the Road Research Station, D.S.I.R. (Harmondsworth), the Royal Aircraft Establishment (Farnborough), and the Telecommunications Research Establishment (Great Malvern).

Last year's exhibition demonstrated the remarkable progress achieved during six years of war in applying electronic techniques to new fields outside radio, such as the precise measurement of physical quantities and the accurate control of industrial processes. This year new evidence of these trends can be seen on the stands of many exhibitors. Since a detailed review of the exhibition is outside the scope of these columns, we shall confine our account to a brief description of a few of the many interesting exhibits.

EVERSHED AND VIGNOLES, LTD.

Normally the relatively low torque gradient that is available with electrical data transmission systems (such as the Admiralty pattern Magslip and the Selsyn systems) is insufficient for direct power control. If the mechanism to be controlled possesses any considerable inertia it is necessary to amplify the output of the transmitting unit by introducing a servo link. One method of doing this is demonstrated by Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, W.4, using a vibrating relay with Selsyn transmission equipment to control a fractional horsepower d.c. servo motor.

The general arrangement of the system is shown in Fig. 1, and the operation, briefly, is as follows: Any misalignment between the transmitting unit and the resetting unit causes a corresponding deflection in the differential unit. For small misalignments with normal low-speed following, the armature A of the relay vibrates continuously under the action of the electromagnet B and so does the rocker arm E of the reversing switch to which the armature is directly coupled. The regulating switch, by reversing the current through the motor M in proportion to the degree of misalignment, ensures smooth follow-up.

For large misalignments, however, the movement of the sensitive arm C is sufficient to hold A at the extreme limit of its travel and against magnet B. In this position contacts D short circuit the resistance R in series with the motor armature and allow the motor to run at full speed.

In its neutral position, the reversing switch E short circuits the armature circuit, and as the shunt field of the motor is constantly excited this results in adequate braking to prevent overshoot.

The sensitive contacts carry comparatively small currents and are provided with condensers for spark quenching purposes.

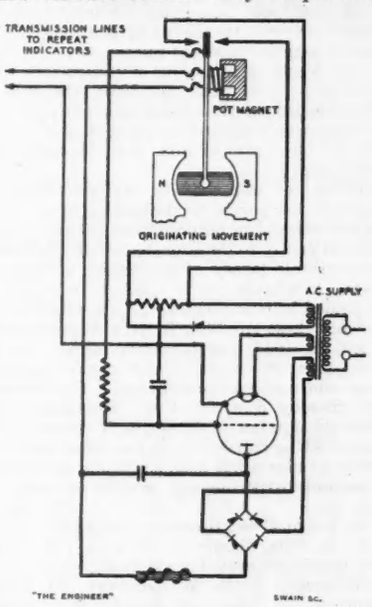


FIG. 2—ELECTRONIC REPEATER—EVERSHED AND VIGNOLES

Another interesting exhibit is the electronic repeater, which is used for distant indication over G.P.O. lines of variable physical quantities. The chief advantages claimed for the system are that it uses direct current with simple d.c. indicators and that the accuracy of repetition is independent of line resistance and supply voltage.

As shown in Fig. 2, the originating movement exerts a torque proportional to the variable physical quantity on an arm carrying a coil and a contact. The coil works in a pot magnet and the contact, which is on the end of the arm, works between two fixed contacts. The coil is in the anode circuit of a triode valve, this circuit being completed through the distant indicators and recorders which are connected electrically in series. The contact carried by the arm, *i.e.*, the centre contact, is connected to the grid of the valve, while the two outside contacts carry positive and negative biasing voltages, respectively, to alter the anode current of the valve as required.

Normally the current through the coil is such as to provide an equal and opposite torque to that provided by the quantity under measurement. But if the quantity changes, and hence the torque, then the arm is moved over and one of the biasing contacts is made; the anode current is thereby increased or decreased as required until the centre contact again moves clear, when the two torques become balanced. A condenser and resistance are connected across the grid circuit of the valve to provide storage of the required biasing voltage. The system thus supplies the transmission lines with direct current, which is proportional to the physical quantity being indicated.

ADAM HILGER, LTD.

The apparatus shown by Adam Hilger, Ltd., 98, St. Pancras Way, Camden Road, N.1, falls into both the trade and research sections of the exhibition. Prominent amongst the former class is the new Chance-Hilger refractometer, which has been specially developed in the laboratories of Chance Brothers, Ltd., for the accurate determination of the refractive

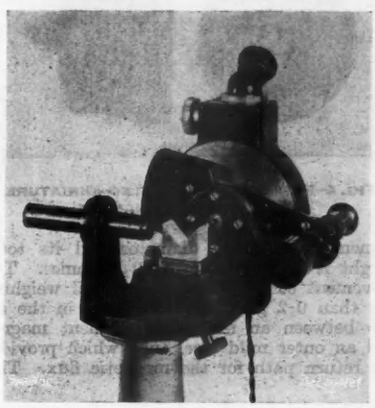


FIG. 3—REFRACTOMETER WORKING HEAD—ADAM HILGER

indices of transparent solids. This instrument is claimed to be capable of a degree of accuracy comparable with that formerly obtained with high precision goniometers using accurately worked prisms; the accuracy is considerably higher than that obtainable with the normal types of critical angle refractometers.

The specimen, which need not be worked with a high accuracy of angle and can have grey surfaces, is placed in a glass Vee-block (Fig. 3); optical continuity of the system is secured by a suitable contact liquid on the inter-faces. The difference in refractive index between the block and the specimen results in a deviation of the collimated pencil of light incident upon the block, and is measured by the angular movement of a telescope rotating about a horizontal axis. To measure this angular movement the working head of the instrument incorporates a glass circle with a very accurate optical micrometer of the microptic type manufactured by E. R. Watts and Son, Ltd.

Since there is no necessity for the Vee-block to be of very high refractive index it can be made of relatively hard glass, which is not

easily susceptible to abrasion by the specimens. The accuracy of reading is materially assisted by the symmetrical field of view which resembles a spectrum with a wide slit. Each slit image is bisected along its greater axis by a fine thread upon which the cross lines in the telescope can be set much more accurately than they can upon an unsymmetrical target, such as the boundary between light and dark portions of the field of a critical angle refractometer.

In the form demonstrated, the instrument is suitable, primarily, for use with solids. Another version of the instrument, with an enclosed water-jacketed prism for use with liquids, is now in preparation.

Other exhibits in the trade section include a range of X-ray diffraction cameras and the new Westinghouse-Hilger spectroscopic spark source. This apparatus incorporates metal rectifiers to charge a bank of condensers to a pre-set constant potential. An ignitron discharges the condensers through the primary of an h.t. transformer, to the secondary of which is connected the usual condenser, inductance and analytical gap. Thus, each time the spark forms, a uniform amount of energy is injected into the system instead of relying on the random conditions that obtain when a discharge is produced by a simple spark set.

NALDER BROTHERS AND THOMPSON, LTD.

One of the smallest and lightest moving coil movements yet produced is shown incorporated in various instruments on the stand of Nalder Brothers and Thompson, Ltd., Dalston Lane Works, London, E.8. The measuring

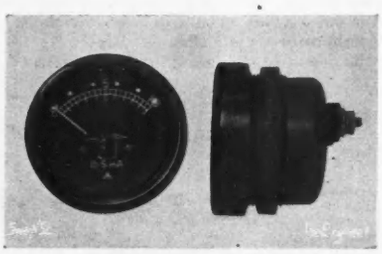


FIG. 4—HERMETICALLY SEALED MINIATURE MICROAMMETER—NALDER

element is 0·6in in diameter and its total weight is of the order of 10 grammes. The movement comprises a moving coil weighing less than 0·2 grammes and works in the air gap between an internal permanent magnet and an outer mild steel tube which provides the return path for the magnetic flux. This

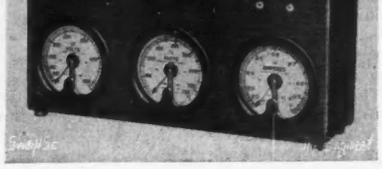


FIG. 5—COMBINED PORTABLE A.C. TEST SET—NALDER

tube also serves as an effective magnetic shield against the influence of external stray fields.

One such movement, arranged with centre zero for use as a portable galvanometer, has a range of 50–0–50 microamperes, with a coil resistance of 70 ohms. A similar movement, mounted in a 2in diameter glass case, gives a range of 800–0–800 microamperes, with a coil resistance of 10 ohms. Of similar design is the hermetically sealed 1½in diameter microammeter illustrated in Fig. 4. This instrument, which is proof against water, shock and vibration, is suitable for use in Arctic as well as tropical climates, and complies with all the requirements laid down in the recently published Wireless Telegraphy Board Specification No. K. 115 for 1½in moving coil meters.

A useful addition to the range of portable multi-instrument test sets is a three-phase, balanced load, circuit analyser shown on the same stand. As illustrated in Fig. 5, this test set comprises four 4in diameter dial instruments with circular scales, for directly measuring current, voltage, power and power factor. The current coils of the wattmeter, power factor meter and ammeter are internally connected in series and are brought out to two current terminals. The voltage coils of the wattmeter, power factor meter and voltmeter are connected in parallel and brought out to three voltage terminals. Each dial instrument has a scale length of approximately 9in.

(To be continued)

Limits of Torsional Vibration Stress in Marine Oil Engine Shafting*

By Dr. S. F. DOREY

THE object of this paper is to present a basis of torsional vibration stress limits, whereby it is hoped ultimately to achieve a highest common factor of agreement upon the important question of what constitutes a safe torsional vibration stress.

The value of such a basis to the designer, as also to those engaged in classification, is obvious, but to be fully effective, any proposals must inevitably take cognisance of the cumulative experience of industry as a whole and receive its general support. The paper, therefore, sets out to describe the considerations which have led to the framing of the proposed basis and the experimental and service results upon which it is founded.

Having regard to the shortcomings of existing methods of torsional vibration stress calculation, it is to be emphasised that the recommendations are based on actual measured stresses referred to the plain portions of the shafting neglecting stress raisers.

As a result of numerous investigations into shafting failures prior to 1939, the author recommended at that time somewhat conservative stress limits of ± 2000 lb per square inch for large crankshafts and screwshafts at service speed.

During the war shafting failures tended to increase, due partly to difficulties of avoiding major criticals at reduced revolutions in convoy and partly to deteriorated shaft alignment, an inevitable legacy of the longer periods between overhauls and quicker turn-rounds demanded by war service. In an endeavour to mitigate these troubles, Lloyd's Register introduced, in 1944, requirements calling for the submission of critical speed calculations for main and auxiliary machinery. The information thereby centralised has included a considerable number of torsiograph results. The Society's long experience in the investigation of shafting failures has been supplemented by two important experimental results during the war, *viz.* :—

(*a*) Large-scale reversed torsional fatigue tests on 9¾in diameter, 35 tons per square inch quality intermediate shafting.

(*b*) Similar tests in Germany on 9·65in diameter, 35 tons per square inch quality crankshafts.

The sum total of the experience thus acquired has provided the basis for the present recommendations.

The stress limits have been divided into three separate sections, namely :—

(1) Crank and screwshafts.
(2) Intermediate shafts.
(3) Thrust shafts.

* Institution of Naval Architects. March 27th.—Synopsis.

Three diagrams show in graphical form the recommended values in each case for 18in and 4in diameter shafts, respectively.

Crank and screwshafts have been treated similarly, since it has been found that under unfavourable conditions these shafts are liable to fail under vibration stresses of approximately the same order.

To each category of shaft limits have been assigned for the maximum stresses considered safe under conditions of continuous operation. Allowance has also been made for size effect; thus, for 18in and 4in diameter crank or screwshafts the recommended limits for continuous operation would be about ± 3000 lb per square inch and ± 4000 lb per square inch, respectively.

Where stresses unavoidably exceed these values, limits are indicated for the maximum severity of transient criticals which have to be negotiated when manœuvring and for the range of speeds in way of the critical which should be " barred " for continuous running.

The general principle adopted is that the speed range in the vicinity of the service revolutions should be well clear of appreciable vibration stresses, whilst progressively more severe stresses could be tolerated below service speed and also above, as when racing.

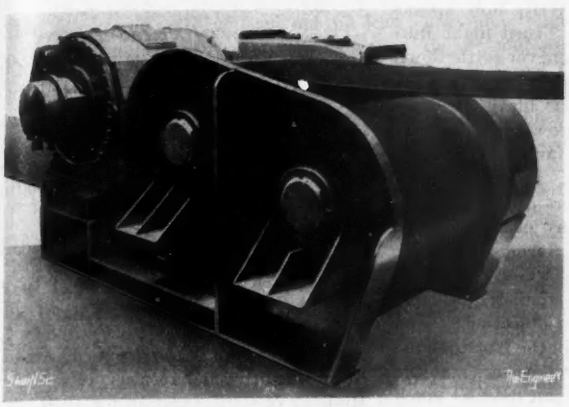
Auxiliary machinery of 100 b.h.p. and upwards has been treated on somewhat similar lines, except that the recommended limits for continuous operation are about 10 per cent greater than for propelling machinery, and are made applicable to both crankshafts and transmission shafts, having regard to the stress raisers frequently found in the latter. In view of the relatively fewer starts and stops generally applicable to auxiliary machinery, considerably higher limits for transient vibration stresses are indicated, of the order of 40 per cent greater for 6in diameter crankshafts. Mention is made of an interesting test carried out in collaboration with a well-known firm of engine builders, in which a 5½in diameter crankshaft of 30/35 tons quality was tested to destruction by running the engine on the major critical at a stress of ± 15,000 lb per square inch and withstood approximately 300,000 cycles before failure. It is considered that a range of speed ± 10 per cent of full load revolutions should be maintained clear of important stresses due to transient criticals.

Subsidiary recommendations are made in relation to vibration dampers, which the author would in general prefer to see applied to deal primarily with transient criticals, to accuracy of tachometers, to propeller moment of inertia, to governing arrangements to crankshaft fillet radii and oil holes and to flank effects of adjacent criticals.

NEW TOWN AT HARLOW, ESSEX.—In his letter to the local authorities, designating Harlow, Essex, as the site for a new town, the Minister of Town and Country Planning has made observations on points raised concerning adequate water supply and sewage disposal. The Metropolitan Water Board and the Lee Conservancy made representations to the effect that the discharge of further sewage effluent into the River Lee might jeopardise part of London's water supply. The Minister says that he has examined these representations in great detail and has obtained reports from independent consulting engineers on both questions. He is satisfied, after considering the reports, that the provision of an adequate water supply will not entail any great engineering difficulties. The arrangements for the disposal of sewage have also been discussed with the Ministry of Health and the representatives of the Metropolitan Water Board and the Lee Conservancy Board. This problem presents more difficulty, not so much in itself as in the use at present made of the River Lee for supplying water to London, and in the fact that the Metropolitan Water Board and the Lee Conservancy Board are anxious about the river's condition. Provision can be made, however, for the disposal of sewage from the new town in such a way as to prevent additional pollution of the river at the water supply intakes, and to fit in with any proper plan for future development which the Metropolitan Water Board and the Lee Conservancy Board may propose, although major works will be required.

A 200 H.P. Coal Conveyor Drive

A POWERFUL new driving gear for trunk conveyors in coal mines has recently been added to the extensive range of mining equipment made by Mavor and Coulson, Ltd., of Bridgeton, Glasgow. It is designed to transmit 200 h.p. to the conveyor belt, when the belt speed is 450ft per minute, and is particularly suitable for driving long conveyors delivering large outputs.



CONVEYOR DRIVING GEAR

The new driving gear is shown in the photograph we reproduce above, whilst the proposed method of installation is shown in the diagram below. The third illustration, shows the machine in the three main component parts into which it can be separated for ease in transport.

The driving motor operates on a high voltage system and its power output is up to 200 h.p., continuous rating. It is totally enclosed and certified flameproof. Automatic switchgear arranged to suit the working circumstances gives sequence control, and, in association with a speed switch driven by the belt, prevents excessive belt slip.

The large tonnages now handled make complete control of the belt even more important than before, and in particular require that the conveyor can be stopped promptly and surely. Without a brake, a downhill conveyor that is loaded might continue to run forwards, and an uphill conveyor similarly might run back. In both cases the necessary control is provided by an effective brake fitted to the new gear. The brake drum is on an extension of the motor shaft, between the flexible coupling and the motor pinion. Directly the motor is switched on, an electrically controlled hydraulic cylinder releases the brake. When the driving gear motor is switched off, or there is any interruption of the power supply, a weight applies the brake and brings the conveyor smoothly to rest.

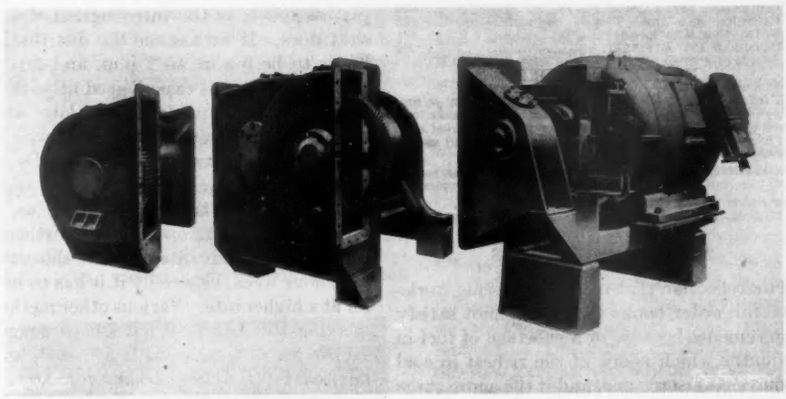
Speed reduction is carried out in two stages. The first stage is by double helical gearing; the spur wheel of this gear can be seen on the central component part of the machine illustrated below. It is mounted on a short shaft, on which is cut the second motion pinion. The second reduction is by straight-cut spur gearing. The pinion drives a spur wheel on the shaft of one driving drum, and this spur wheel meshes with an identical wheel on the other driving drum shaft, so that the two drums are driven at the same speed in opposite directions. All gearing is machine-cut, heat-treated, and runs in oil.

The driving drums are of cast iron, machined to close limits over their working faces and cambered to aid true running of the belt. Care is taken in machining to ensure that the peripheral speed on both drums is the same. Adjustable scrapers are fitted to clean any dirt off the drums when working, and by keeping the effective diameters correct, ensure that the speeds of the driving surfaces remain constant and equal. The number of plies and weight of duck in the belt decide the diameter chosen for the driving drums; it is 3ft 6in in the gear which we illustrate. Although no snub pulley is used, the arcs of contact between belt and drums are the largest that are possible with two drums. The necessary powerful drive can therefore be transmitted to the belt, and the greatest possible length of belt can be driven.

The drive is on the bottom belt for convenience of installing, operating and inspecting. At the delivery end the use of a plain head pulley, instead of a driving drum, saves headroom and lessens the drop of the coal. The top belt, carrying the coal, passes over the gear, and is supported on inverted troughing or other structure slung from the roof, with a turnbuckle attachment to link the troughing to the driving gear.

Self-aligning roller bearings fitted to the machine are designed and arranged to give long life under arduous conditions. All bearings are sealed in cast iron housings, which are removable for ease in dismantling and oil or grease seals are fitted to keep dust or grit from penetrating along the shafts into the bearings. Only three sizes of bearings are used throughout the gear, so that only a few need be carried as spares.

The bearing housings are carried in two fabricated steel plate cheeks, one being on each side of the driving drums. One of the cheeks also forms an oil-tight chamber containing the gearing. At the rear end of the gear stools and channels bolted to the cheeks carry the motor and the brake. The self-contained structure thus formed possesses great rigidity in proportion to its weight, and ensures that the alignment of all parts is maintained. The flat lower surface is drilled ready for bolting directly to the foundation, and no understructure is required.

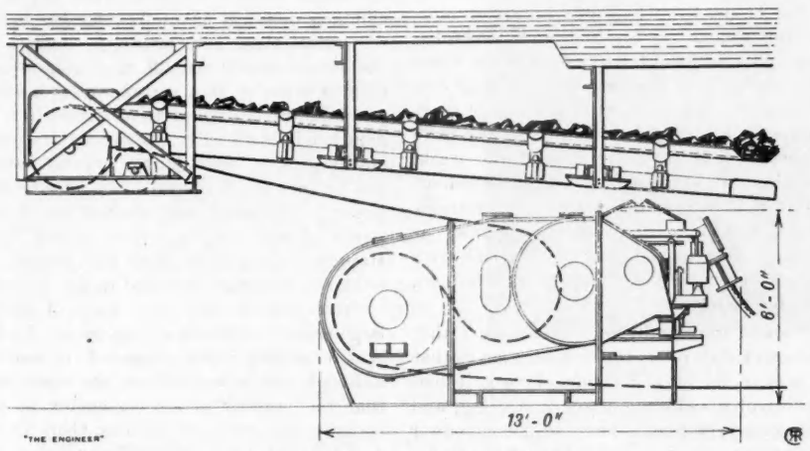


DRIVING GEAR DISMANTLED FOR TRANSPORTATION

Webbed side-brackets are provided to give a convenient hold for raising or lowering the gear when placing it on a foundation or adjusting its position.

For ease of transport, the whole gear can be divided into three parts, as shown at transverse joints in each cheek. The first part carries one driving drum and its spur wheel; the second the other driving drum, together with its spur wheel and the first motion shaft; the third part consists of the motor, brake, motor pinion, and associated structure. The third part can be divided again if necessary by removing the motor. The gear can therefore conveniently be handled in three or four parts of only moderate size, and readily put together again in true alignment.

Low divisions inside the gearcase form oil-baths into which the three spur wheels dip, and the bearings are lubricated effectively by oil lifted by the gearwheels. Each oil-bath has an oil level plug, a drain plug, and a large handhole cover at the top, through which inspection can be made and oil added when necessary. The two bearings, at the outer ends of the drum shafts, are lubricated by grease, and protected against dust and grit by labyrinth seals.



INSTALLATION OF DRIVING GEAR

THE ENGINEER

APRIL 11, 1947

VOL. CLXXXIII No. 4759

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

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STAGGERING HOURS

THE reflection that most engineering works have full order books and yet cannot satisfy requirements because of a shortage of fuel in a country which is one of the richest in coal resources is a sorry one, and if the acute stage has been passed with much hardship and the sad spectacle of an industrial stoppage, the problem arises as to the best way of recovering lost ground and of obtaining maximum production with the power that is available. The old legal maxim *Actus Dei vel legis nemini facit injuriam* seems hardly apposite at the moment in that the inclement weather, the floods and the gales have definitely had an adverse effect on recovery, while various enactments of the Government can hardly be claimed to be prejudicial to no one. According to official pronouncements, our difficulties will be largely mitigated by the staggering of hours, but the application is none too easy. For years the London Passenger Transport Board has urged the staggering of working hours as a means of spreading peak loads and giving more reasonable conditions of travel, and Government Departments and others did their best to co-operate, but it must be confessed that results did not approach those anticipated. At the same time it is logical to do the utmost to make the call on the supply of power as uniform as is possible. The subject of staggering hours is one that demands careful consideration.

The two most promising alternatives would appear to be a day and night shift and a double day shift, but there are other suggestions; yet we find that after discussing the position with those most interested, it is a case of *tot homines quot sententiae*. At first glance the idea of a day and night shift would seem to be the simplest solution, although it must be conceded that in certain quarters there is a rooted objection to regular night work; indeed, if we go back to one of the earliest books of Holy Writ, Job speaks deploringly of those who "turn night into day." Certainly some can never settle down to night work, as they find it impossible to sleep by day. Again, home life is seriously disturbed by night workers, particularly when some members of a family are on day duty and others on nights. It has also been argued that female workers are opposed to night work, although many of them did it steadily and efficiently during the war. Finally, when we remember that a night shift is more expensive than a similar day shift, we have set out the main objections. The very great advantage lies in the fact that the power situation is so much better, and the cry is often heard, "You can have as much power as you like at night." Turning to the double day shift, we are again confronted with inherent objections, among which may be cited the impossibility of maintaining two full shifts, the very awkward distribution of hours, which probably harass the housewife just as much as the introduction of a night shift does. If we assume the distribution of hours to be 6 a.m. to 2 p.m. and 2 p.m. to 10 p.m., trouble is experienced at both ends, for there is a tendency to late arrivals in the early morning, while those who begin work at two o'clock are prone to be active in their own interests prior to going to work, for which they are not as fresh as when normal hours are in operation. Furthermore, there is the disadvantage of the short thirty-four-hour week, especially if it has to be paid for at a higher rate. Various other methods of meeting the difficulty have been suggested, each with certain advantages, such as that devised for the Wolverhampton area by a committee of local industrialists and workers and approved by a number of firms. The scheme most generally favoured is to arrange to dispense with electricity one day in the week on an agreed rota system, the area being split into five geographical divisions, each of which is subdivided again into six groups. By this means the electric load is fairly distributed, there is less dislocation in the home circle, while the worker gains the clear day to himself. What effect the limiting of sport to the week-end will have on those who have their day off in the middle of the week, remains to be seen. A useful expedient adopted by a number of firms is to transfer to night shift as many heavy machines as possible, thereby reducing the day load with the transfer to the night of a minimum number of workers.

Viewed impartially, it would appear that the night shift offers the best solution in that it is more flexible as to hours of work, it does not involve awkward hours of starting, and it has the very great advantage of using power at a time when it is least in demand for domestic and purposes other than industrial, whereas the two-day-shift business requires power at the same time as all other users. The relative costs are not so easy to assess as they must be affected to a considerable extent by the numbers employed and local conditions. "One man's meat is another's poison" is very true, and it is doubtful whether there is any simple solution, as there are so many variables. Local prejudices must also be allowed to weigh; indeed, it is felt that much must be left to be sorted out amicably in different areas of the country.

CIVIL AVIATION TO-DAY

DURING the past winter all forms of transport have been gravely affected by the exceptionally severe weather, and in the universal blizzard the civil air services, naturally, did not escape. This was seen in reduced services, in unusable aerodromes, and in a regrettably large number of fully publicised accidents. As the worst weather came at or after the turn of the year, the 1946 figures cannot be expected to reveal its full effect. Apart from such adverse and uncontrollable factors, the safety figures are showing signs of a welcome improvement. According to the returns issued by the Ministry of Civil Aviation for 1946, air lines based on this country flew 358 million passenger-miles and carried 459,000 passengers, with a passenger-accident ratio of 8·1 deaths per 100 million passenger-miles. As the accident rate for the five-year period just before the war was five times as high as this, it will be realised that the great effort made in recent years to increase safety in the air has been rewarded. Nevertheless, there is much to be done. Last year's figures for the United States Air Services show that the passengers carried were 13 million—twenty times as many as here—with a fatality rate as low as 1·2 per 100 million passenger-miles, an 85 per cent improvement on ours. America, it must be admitted, leads the way in respect both of traffic density and of safe travel. But since the denser the traffic the greater the means available for improving airfields and radio aids, the two would naturally be expected to go together. Nevertheless, we cannot fall short of aiming at the same high standard of safety. When this topic is under discussion in Parliament or outside, the public are not helped by suggestions that crashes have little relation to engine power; for many crashes do arise from failure of climbing power at take-off. One has but to remember that horsepower is defined as the power needed to lift a certain weight (33,000 pounds) at a certain rate (one foot per minute) to realise that the ability to gain height with sufficient rapidity to avoid crashing into surrounding objects cannot but be very much indeed a matter of engine power. The total load carried per horsepower should not exceed a certain limit. Happily, it appears that the aircraft of 1947 will be better provided in this respect.

From time to time one hears of certain large aeronautical enterprises in the United States getting into financial difficulties, although one is assured at the same time that the number of air passengers in that country has risen by no less than 78 per cent between 1945 and 1946; it seems difficult to harmonise the two. Perhaps the answer is contained in the forecast made two years ago by Mr. Furnas, the research director of the Curtiss-Wright Corporation,

that although by 1950 the passenger-miles figure may rise to no less than 12,000 million, yet with the natural growth in efficiency of operation and the larger aircraft to be expected, quite an astonishingly small fleet of air liners will suffice to carry the whole traffic. In fact, on the basis of a five-year life, the annual air liner replacement figure might be less than 200, which, for a country which in a single year of the war could and did turn out no less than 100,000 military types of various sizes, certainly does not suggest a very heavy future order book for the manufacturers. The new air liners will be much larger craft; present ones seat on the average twenty-five passengers apiece, but the plan now is to build much larger ones, since small ones cause congestion at airports on account of the numbers needed to carry the growing traffic. It was at one stage expected that last year's current orders for American air lines might amount to as much as a hundred million pounds, of which about one-seventh would have been exported, but the figure may be a good deal less now. Any gap in orders may, in some measure, be filled by those for private aircraft, though the proposed universal stiffening of flying regulations in the interests of safety is likely to limit the demand.

Fewer details are published about the position here. From Parliamentary statements it seems that we are spending some ten millions a year in subsidies of various kinds, but we are less informed as to details. It seems, oddly enough, that under private enterprise, it was easier for the public to know the state of the aviation financial balance sheet than it is under our new socialised organisation, in which we, in theory, are all of us shareholders. Subsidies are more obvious between a Government department and an air-transport firm than between one Government department and another; moreover, Government ownership usually implies large overheads in some form or another; it is remarkable how large a staff is needed to be prepared for demands from Parliament for information on almost any subject. Large staffs need a high traffic density to carry them. That was one argument used in favour of the existing forms of transportation being encouraged to take a big share in air transport. But high traffic density may be difficult to achieve in this country until the present years of austerity have passed, and even then, to become really popular, flying will have to be made much cheaper and much safer than it is at present. In both respects there will, in these days, be a need for patience on the part of the public, even though the ultimate issue may not be in doubt.

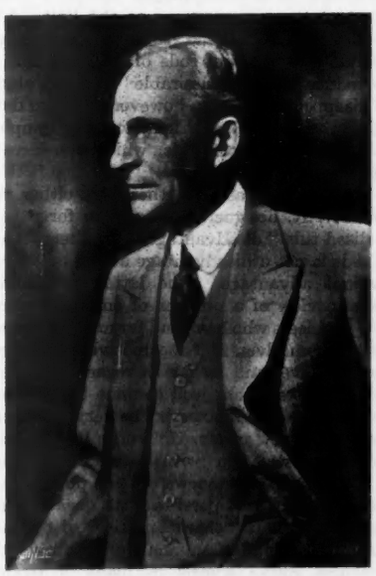
Obituary

HENRY FORD

THE death of Henry Ford, which occurred on the morning of April 8th, is an event which has aroused universal regret, for it can be safely said that he was known—by name at any rate—in every country in the world. He was indeed a veteran of the automobile industry, and whilst he will be long remembered by the developments which he brought about in that industry, his energy, organising ability and business capacity are outstanding features of his long life, which will not be quickly forgotten.

Henry Ford was born on July 30, 1863, on a farm at Dearborn, Michigan, U.S.A., and claimed, as his earliest recollection, that "there was too much work on the place." He went to the district school and when he left, at the age of seventeen, he was apprenticed in the machine shop of the Drydock Engine Works, a move with which his father was evidently not very sympathetic. In "My Life and Work," Ford recounted how, as a boy of twelve, he saw a traction engine for the first time, and how that encounter fired his enthusiasm for making a "machine that would travel the roads." That ambition was well realised. He built a steam car that ran, and then went on to follow closely the progress of the gas engine. In 1887, Ford built an engine running on the Otto four-cycle principle, and although he had then returned to the work of a farm, he found time to study everything on which he could lay his hands concerning how gas engines were made and how they worked.

Soon after this, Ford went to work with the Detroit Electric Company, and spent his spare time in a workshop erected at the back of his house in Bagley Avenue, Detroit. It was here that the first Ford car was completed in 1892, although it was not until the spring of the following year that it ran to Ford's satisfaction. It had two cylinders, 2½in bore by 6in stroke, and developed about 4 h.p. The power was transmitted from the motor to the countershaft by a belt and from the countershaft to the rear wheel by a chain. The car had two speeds, one of ten



HENRY FORD

miles per hour and the other of twenty miles per hour, and held two people, the seat being suspended on posts and the body on elliptical springs. The total weight of the car was about 500 lb. It was the first and for a long time, the only motor car in Detroit, and very naturally it excited the curiosity of many people. So much so that Ford himself said that, finally, he had to carry a chain and look it to a lamp-post whenever he left it anywhere.

Henry Ford sold this car in 1896 for 200 dollars, although later on he bought it back again for half that price. In the same year he started on the construction of a second car, all the time looking ahead to full production. It was not until 1899, however, that he left the Detroit Edison Company to devote all his time to the motor car business, and then he had no personal funds. With a group of men who were of a speculative turn of mind, he organised the Detroit Automobile Company, in which he held a small amount of the stock and of which he became chief engineer. He severed his connection with this concern in 1902, however, and then rented a shop in Park Place, Detroit, in order to continue his experiments. In the following year the Ford Motor Company was formed, and Henry Ford developed his car to a stage where its speed attained some significance.

His autobiography gives an account of his car-racing experiences at Grosse Point, and also explains that when the Ford Motor Company was formed, its capital was 100,000 dollars, of which Ford himself owned 25½ per cent. The story of the company's growth is well known, and emphasises the characteristic determination of its founder. Its first advertisement proclaimed that the company's purpose was "to construct and market an automobile specially designed for everyday wear and tear," and before very long, Henry Ford was building up a business organisation which, with all its allied undertakings, has achieved a world-wide reputation, not only in passenger and commercial vehicles, but also in power farming implements. The details of that organisation were not overlooked in the building-up process, a fact which is exemplified by Henry Ford's requirements so far as his agents were concerned. He insisted that they should be progressive, up-to-date men, keenly alive to the possibilities of business; that they should have an adequately equipped repair shop which had in it the right machinery for every necessary repair and adjustment; they must be mechanics thoroughly familiar with the construction and operation of Ford cars; and there was an insistence upon absolute cleanliness throughout every department, with no unwashed windows, dusty furniture, or dirty floors.

Much more could be said of the technical achievements of Henry Ford and the organisation which bears his name, not forgetting the construction of the bomber plant at Willow Run in the recent war, and also the Ford output of tank engines and armoured cars. But, alongside them all, Ford's career as an industrialist and his views on industrial affairs cannot be overlooked. To many of these views he gave expression in "Today and Tomorrow," a book which was written in 1926, when the world was approaching an economic depression. On the matter of the five-day week he said: "In our own factories we find that we can get more production in five days of eight hours each than we could get in a six or seven-day week of ten hours a day. The extra day of leisure is going to bring large results, for the people will learn more about living, will have time to expand their sense of need, and therefore will increase their consumption." Another opinion of Henry Ford's was that the majority of labour troubles are caused by managers who have no first-hand knowledge of labour, but in spite of this

opinion he had on occasion to contend with strikes in his own organisation, particularly in 1933, when he agreed to a thirty-two hour week at the same rate of pay as for a forty-hour week.

Henry Ford was a firm believer in the efficacy of private enterprise. "We are living in an age," he wrote in 1926, "when it is possible to use power and machinery in the public service—and at a private profit." At that time his counsel was not to bother about the future, saying that "the future has always cared for itself in spite of our well-meant efforts to hamper it," but of him it can be remarked that the initiative shown in his early days helped him to achieve a high position both in the realm of automobile engineering and in the world of business.

Although Ford relinquished the presidency of his company in 1919, he took office again in 1943 on the death of his son, and from 1943 to 1945 served as general manager. He was a member of the Society of Automotive Engineers, and also took a keen interest in archæological matters.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BURNING OF SLACK ON OPEN HEARTH

SIR,—Referring to "Prior Lien's" letter in your issue of March 14th, I have found, for domestic use, that a simple method for the consumption of anthracite dust in a kitchen boiler can be effected by making up small cubes of a mixture of dust and cement in the proportions of 7 to 1.

My general method is to riddle the anthracite through a ¼in mesh, mix with cement and add enough water to form a stiff mixture.

A trowelful placed on a half sheet of newspaper and wrapped as one would parcel half a pound of currants is left to dry. The result is a briquette clean to handle and which burns very well when used as a supplement to the anthracite nuts. One could, of course, make cubes in a suitably divided frame, but the wrapping method is simple and requires no apparatus.

There is a considerable amount of dust and ash formed, and the ashpan requires more cleaning out than is usual with good fuel in this type of boiler.

I do not know whether this method would prove satisfactory on an open grate, using coal dust in the mixture.

There may be better methods in use by other readers, and it would be interesting to hear of same, as there is no doubt that most people are very short of fuel and yet possess an amount of bituminous dust, which, owing to the difficulty in consuming, is left unused.

J. D.

London, March 24th.

LOCOMOTIVE VALVE GEARS

SIR,—I do not wish unduly to trespass upon your space, but it would appear that in addition to risking a charge of pedantry, I have incurred the much more serious charge of ambiguity.

Possibly I may be allowed to endeavour to make the position clear.

It is an inherent feature of all radial valve gears and of valve gears of the Gooch or Walschaerts type, which are frequently referred to as radial gears, that they give a constant lead, and to make this point clear they give an amount of port opening with the piston on either dead centre, which does not vary as the gear is notched up. (To put this another way, when the gear is properly set up, with the piston on either dead centre, the reversing lever (or other operating mechanism) can be moved from "fore" to "back" gear without moving the valve at all). The angle at which the valve is opened is, of course, advanced.

With such gears as Stephenson's and Allan's, in addition to the *angle* of advance increasing as the gear is notched up, so also does the amount of port opening at dead centres; in other words, in contradistinction to the fixed lead given by the radial gears, Stephenson's and Allan's gears give a variable lead. Dr. Tuplin says that this is a disadvantage to be minimised by adopting a valve setting giving negative lead in full gear. He may be right, but some very capable locomotive engineers will not agree with him, as many of them are of the opinion that this very feature is one of the greatest value in locomotive work. It is perhaps significant that Mr. Churchward, one of the greatest authorities on locomotive valve gears, always preferred Stephenson's gear where it could be properly applied, and fitted it to all the two-cylinder engines on the G.W.R., a policy still in vogue on that railway to-day. He only used Walschaerts gear (or in one odd case, a variation) for his four-cylinder engines because there was not room to fit a mechanically sound Stephenson gear.

If Dr. Tuplin is right about this characteristic of the gear being a disadvantage, why do the G.W.R. people go out of their way so to design their version of it as to emphasise this "disadvantageous" characteristic? The amount of this automatic increase in advance (always referring to gears with an open rod arrangement) is conditioned by the general proportions of the gear, being chiefly influenced by the proportionate length of the eccentric rods, and to a lesser degree by the distance apart of their connections to the link. Now in the G.W.R. layout, there is ample space available to allow of rods of such a length as to reduce this "undesirable" feature almost to disappearing point; however, far from doing this, the G.W.R. design actually employs comparatively short rods, which considerably accentuate the feature.

We can only assume, therefore, either that the G.W.R. designers have not in forty years realised this "disadvantage," or, alternatively, that it is not a disadvantage at all, but a very distinct advantage. The latter is the very definite view of a number of eminent locomotive engineers who have had far more experience with locomotives and locomotive valve gears than I have, and so far as regards that part of the matter I am well content to let it rest at that; it would, however, be very interesting indeed, in view of Mr. Holcroft's intimate and lengthy association with locomotive design, to have his further views on this point.

Dr. Tuplin still persists that negative lead in full gear is a "characteristic" of Stephenson's gear, and as an analogy to prove this instances round wheels in place of twenty-sided polygonal wheels as being modern practice.

The analogy is a poor one; round wheels have been in use for thousands of years. There are still, in this country, some thousands of locomotives with Stephenson gear and positive lead in full gear, whilst there must also be thousands of marine engines with similar characteristics.

Negative lead in full gear is not a characteristic of this gear at all, and for many purposes, marine amongst them, is in no way desirable; it is a form of valve-setting which is highly desirable to make the most effective use of Stephenson gear when applied to fast-running locomotives designed to work at short cut-offs; that and nothing else.

K. N. HARRIS.

Wealdstone, March 31st.

THE ARK OF NOAH

SIR,—It is one of the tragedies of the recent power cuts that we have been deprived of your comments on the Ark models at the Worshipful Company of Shipwrights' Exhibition, promised on page 127, January 31, 1947, issue.

They were fascinating models, as you remark, and represent an impressive amount of deduction and reading between the lines, for the specification extends only from Gen. 6, 14 to 6, 16.

The Ark story deserves more attention from technical men than it has hitherto had, for there is hard fact behind the poetry of the Old Testament. Her size alone is strangely exact; (Gen. 6, 15), and the dimensions given are those of a ship of 14,000 tons; not unreasonable for the load of men and animals, and the stores of food needed for a voyage of a year and ten days (Gen. 6, 11 and 8, 14).

On this score alone, could she have been the traditional mixture of sampan and Upper Thames houseboat? True, there is a case for the ridged roof, since in "Moons, Myths and Man," H. S. Bellamy reasons that the Deluge would be accompanied by showers of cosmic debris, but her hull must have been more ship-form. With the storm at its height, she might be able only to ride to her sea-anchor (which only one entrant provided), but when the peaks of Ararat loomed up, how did Noah beach her without breaking her up? He must have had heavy ground-tackle, and the means of handling it.

The Book of Genesis details a crew of four men and four women (Gen. 7, 13), probably the "afterguard," since the toiling lower-deck are so often forgotten, but no crew could control a 14,000 tonner with sweeps, so we are driven to conclude that she had mechanical power. And why not? Must it always be assumed that all technical development has been crammed into the last two centuries? Surely our profession is older than that? It might be argued that the Deluge itself and the resulting setback to civilisation was the result of an early and ill-advised release of nuclear energy.

Once the "power" premise is faced, other conclusions follow. The shape to which we have grown accustomed could be a folk-memory of a bluff vessel of the ice-breaker or whale-factory pattern, with, at least, enough power on propulsion to drive her safely up the ground. The same plant would be more than adequate for the crude necessities of ventilation and deck-washing, also bilging, damage-control and cold storage.

Are not the two birds (Gen. 8, 7 and 8) catapulted aircraft? Navigation difficulties, caused by the obliteration of all charted detail, and possibly the shifting of the Earth's magnetic axis, would account for the ditching of the "Raven." The "Dove" seems to have been lucky, although Gen. 8, 12, is curiously off-hand about her final loss. Possibly, as the land dried out, her crew walked back.

One gathers that these aircraft were amphibians, and that there were no deck-landing facilities. (Obviously, if we accept the ridged roof.) In Gen. 8, 9, we read that "(Noah) put forth his hand and pulled her (the 'Dove')

unto him in the Ark," or, in modern terms, hoisted her inboard with a crane.

I am convinced that serious investigation along these lines would produce even more revelations, but I fear I will already have aroused the wrath of the orthodox, and so, with some regret, I must sign myself,

"GALLIO."

London, S.E.19, April 5th.

THE QUALITIES OF INVENTIVENESS AND RESOURCEFULNESS IN ENGINEERS

SIR,—It is with pleasure that I submit my opinion on Mr. Charles Baxter's remarks, which appeared in THE ENGINEER for March 28th. In reading his letter, I was impressed with the interest shown towards our engineers of to-day (of which I claim to be one). While I agree with Mr. Baxter, I will endeavour to confine my remarks to the sentence, "The trouble is that such people are not sought, and may be lost to industry for years," and ask whether it has occurred to him that *some* managements, or perhaps I would be more correct in saying, *some* in positions directly responsible to the management, are found to be so jealous of their positions that when the qualities of inventiveness and resourcefulness are shown in anyone under their charge, he soon becomes lost to that establishment, and sometimes to the industry itself. In the midst of studying for my A.M.I.P.E., and claiming to hold my own with any man in the organisation and up-to-date production methods in light engineering, what do I find? I have to watch my step because my ingenuity might be out of place.

I. DAVIES.

Berkshire, April.

COMMON-SENSE OF ENGINEERING RADIOGRAPHY

SIR,—Mr. V. E. Pullin's article in THE ENGINEER of December 13th, 1946, entitled "Common-sense of Engineering Radiography," has only just come to my notice. While I have no criticism of the contents of the article, I feel that I must point out to the engineering world a certain omission.

Modern X-ray technique includes not only radiography, or coarse structure examination, but also stress measurement. This is a somewhat academic technique, an application of X-ray crystal analysis, the precision measurement of crystal lattices. It is possible to measure the stress in steel with an error of not more than about one or two tons per square inch in favourable cases. A radiographer examining a batch of castings sometimes finds cracks due to shrinkage stresses. These usually occur in the same place in each cracked casting, pointing to some fault in foundry technique. These cracked castings are rejected by the radiographer. But what of the uncracked ones? It is a fair assumption that some are severely stressed but have not quite cracked. A little stress in service may be sufficient to crack and fracture them. The uncracked castings should be examined for stress in the suspected region before being passed as serviceable.

Welded structures, from their method of fabrication, always contain stresses. I have met stresses as high as seventeen tons per square inch in welded mild steel structures. Heat treatment can remove them but their presence or absence can be detected by X-ray stress analysis. Welded structures which must not warp in service should be reasonably stress-free. Radiography cannot guarantee this but only that the weld itself is physically sound.

D. E. THOMAS

Woolwich, S.E.18, March 3rd.

Thomas Lloyd: First Engineer-in-Chief of the Navy

THE chief personalities who were responsible for guiding the early technical developments of the Engineering Branch of the Royal Navy are not well known, but their valuable contributions to naval and marine engineering are deserving of widespread acknowledgement. It would appear an appropriate time to recall particularly the work of Thomas Lloyd, C.B., who, on his appointment as assistant to the Comptroller of the Steam Machinery on April 9, 1847, became the first naval engineer to be appointed for duty inside the Admiralty.

Another event of great importance to naval engineers was the issue of an Order in Council, dated February 27, 1847, creating a new classification of engineer officers, including the rank of Inspector of Machinery Afloat. This order also granted commissioned rank to engineers for the first time. What part Lloyd played in the formulation of this order is not known, but as he had been the chief adviser on naval engineering since 1842, his name cannot be dissociated from this significant step in the recognition of the engineer officer.

The details of Lloyd's contribution to the Navy were recorded by his opinions and decisions expressed in the official dockets, reports and other forms of Admiralty and departmental correspondence. Much of this record is no longer available and without access to any private letters this acknowledgement of his work and character is necessarily very incomplete.

He was born at Southsea on October 29, 1803, and educated at the Portsmouth Grammar School, later studying under Professor Inman at the School of Naval Architecture. He completed his apprenticeship as a shipwright at Portsmouth Dockyard in 1825, and was then transferred to Plymouth, being employed as a shipwright until 1831.

It should be recalled that the use of steam machinery in the Navy was in its very infancy. Its introduction may be said to date from the appointment of Simon Goodrich as Engineer and Mechanist at Portsmouth in 1814. He was responsible for supervising the installation of steam machinery in the dockyards, and the maintenance of any steam vessels which first included the Post Office Steam Packets. He was also the adviser to the Navy Board on engineering matters. Lloyd must have had some experience with the Steam Packets while he was at Plymouth, as it was the nearest dockyard to Falmouth, from which most of them sailed for abroad. In 1831 he was directed to turn his attention to the study of steam and its application to marine propulsion. There is a note in the Admiralty records to say that "upon the superannuation of the Engineer and Mechanist in 1831, his successor was appointed by an Admiralty Order of March 17th, at a salary of three hundred pounds. That appointment was declined by him on April 15th next ensuing. The superintendence of the engineering department then devolved upon the Masters of wood and metal mills." Lloyd was appointed as Superintendent of Wood Mills at Portsmouth on April 16, 1831, and it would appear that he became responsible for the steam machinery, but whatever his exact responsibility, his work was intended to give him an opportunity of studying naval engineering. In 1833 he was sent to Woolwich Dockyard, and took the opportunity of obtaining several months practical experience afloat in a steamship.

One of the first references to the supply of steam machinery for Woolwich Dockyard is to be found in the Boulton and Watt work books of the Soho Foundry now in the Birmingham City Library. In October, 1815, instructions were issued that materials for "the forge engine, blowing engine and tilt engine" were to be forwarded "as soon as they can be got ready, to Thos. Burnett Esq. Storekeeper of His Majesty's Dockyard at Woolwich," which was to become the principal repair yard for engines and the manufacture of boilers. In 1835, Peter Ewart, a former apprentice, and one-time employee of Watt, was appointed as Chief Engineer of Woolwich Dockyard, and by the acceptance of this post became the adviser to the Admiralty on steam machinery. Lloyd, who was the younger and less experienced man, became his assistant. In July, Lloyd was again sent to Plymouth, gaining first-hand knowledge of the yard and the maintenance and repair of steam vessels. His association with the West Country was invaluable to him in later years when he had to propose the machinery plans for the Keyham extension. He returned once more to Woolwich in 1838, and remained as Ewart's assistant until the latter's accidental death in 1842. He was then made Chief Engineer in Ewart's place.

STEAM MACHINERY

Lloyd was virtually the technical head of the "Steam Department" for over a quarter of a century. It was a period full of interesting development; inventors were never slow in advocating their material schemes, and even quicker in making their financial claims, and it required a man of exceptional ability and determination to sift the good ideas from the bad, to give a fair trial to all proposals which were based on sound principles, and ensure that only the best were adapted for naval purposes. His experience with Lord Dundonald's rotary engine is an example of the difficulties with which he had to contend. This engine was first tried at Portsmouth, and later fitted in H.M.S. "Janus." Lloyd's criticisms of this engine in 1845 were described by the designer as "ridiculous," and presumably due to the latter's influence, Professor Airy, the Astronomer Royal, was called as a second authority, and in January, 1846, reported "most favourably" on it. Two months later, however, the engine broke beyond economical repair, and Lloyd had to issue the order for its removal from the ship.

This incident must have enhanced his reputation and his advice was much sought after, both inside and outside the Service. He had a knowledge of a great variety of subjects, and like nearly all outstanding men, an exceptionally good memory. Although a comparatively young man, he held a very responsible position; there were numerous maintenance troubles to be overcome, material proposals to be examined and tried, and personnel problems of intense importance to be attended to. There were trials with Hall's condenser, provision of financial estimates for material and wages, problems of incrustation in boilers, gearing requirements for propellers, suggestions for feed regulators, designs for telescopic funnels, proposals for disconnecting paddlewheels, discussions on the use of higher steam pressures, a proposed

form of jet propulsion, trials with "smoke consuming apparatus," and many other items demanding much of his time and thought.

Reliability and simplicity seem to have been two of Lloyd's standards, and his decision that a proposed scheme was "too complicated," or "would cause more trouble than it was worth," was often sufficient to condemn it. The knowledge possessed by most engine-room personnel at that time was very limited, and no one will doubt Lloyd's wisdom in the choice of these two particular standards.

One interesting proposal which needed Lloyd's attention in 1842 was Holdsworth's plan for cooling the "Victoria and Albert," the Royal Steam Yacht, before and abaft the engines and boilers. It was also suggested that in men-o'-war this scheme could render magazine and shell rooms proof against fire. It consisted of water bulkheads of wrought iron, with a pump worked by the engines to keep cold water circulating through them. In a report signed by Lloyd and Oliver Lang, the famous master shipwright, they wrote, "We consider that the bulkheads containing water would have a tendency to keep the engine-room cool, but the reduction in temperature would not be considerable. We therefore are of the opinion that the benefit to be derived from such a plan would be more than counterbalanced by the inconveniences arising from getting out of order, and the difficulty of repairing it."

Screw Propellers

Francis Pettit Smith had taken out his patent for the screw propeller in 1836, and three years later Brunel carried out a series of trials with it in the "Archimedes," but it was not till March, 1844, when Brunel and Lloyd submitted a report on "the peculiarity and advantages" of the Smith propeller that its adoption in the Navy made any real headway. Once the principle had been established that a ship could be successfully propelled by turning a form of screw in the water, it raised widespread interest. During the years 1840-47, the Admiralty was constantly receiving individual suggestions for propeller designs, and the phrase "Mr. Lloyd to report" became almost a standard initial action. Bourne in his "Treatise on the Screw Propeller" (1867) mentions over three hundred different patents and suggestions.

Numerous trials of different propellers in H.M.S. "Rattler," culminating in the famous tug-of-war with H.M.S. "Alecto," in 1845, were mainly the outcome of the Brunel-Lloyd report. Lloyd was also associated with the manufacture of propellers and construction of disconnecting gear, and he was also responsible for the propeller trials carried out in H.M.S. "Dwarf," which was placed at the disposal of the engineers at Woolwich for making further experiments. It was an extremely busy time, and entailed a considerable amount of travelling about the country. One trip of particular interest was in January, 1845, when Lloyd sailed in the "Great Britain" at the request of the Ship Propeller Company. He later submitted a favourable report on her qualities.

In an appendix to the "Treatise on the Screw Propeller," as head of the "Steam Department," Lloyd describes the "introduction and progressive increase of screw propulsion in Her Majesty's Navy," with details of the performance of screw vessels up to March, 1865. In a reference to the multi-bladed propeller he summarises his views by saying, "On the whole, screws of three blades are probably the best for most purposes of ocean service."

Tubular Boilers

Captain Alexander Ellice, R.N., was the Comptroller of the Steam Machinery in 1847, having previously been associated with the Post Office Steam Packets at Falmouth. He had a good grasp of the material and personnel problems. One of his first actions when he took office in 1846, was to demand a list of engineers with details of their appointments and seniority. Prior to this, all the records of engineer officers had been kept by the Captain Superintendent at Woolwich, who was their appointing authority. Captain Ellice, apparently, had a high regard for Lloyd's ability and judgment, for immediate approval was given for his assistant to sign all official letters in his absence from the Admiralty, but there is no known instance of Lloyd having occasion to do this till 1848. It is, perhaps, of interest to reproduce what is probably the first departmental letter to be signed by a naval engineer :—

July 4th, 1848

Commodore Superintendent, Woolwich

Application of Brass Tubes to Iron Boilers

With a view to determine whether Brass Tubes can be advantageously applied to Iron Boilers to a greater extent than has hitherto deemed advisable, I request you will call upon Mr. Atherton (the Chief Engineer) to make a very minute and careful examination of the various parts of the boilers of the "Firebrand" (which are fitted with brass tubes and have been in use above four years) and to report fully their state and condition and particularly whether the juxtaposition of the two metals has caused galvanic action sufficiently powerful to leave perceptible traces of its action in the destruction of the Iron.

Th. Lloyd,
for Comptroller.

The "Firebrand" was one of the first vessels to be fitted with tubular boilers in the Navy.

Lloyd was necessarily concerned with the production of suitable steam coals and the establishment of coaling stages and bases, both at home and abroad. Arrangements were made at Devonport for testing the suitability of coals, and between 1864 and 1867 experiments by representatives of the "Steam Department" were carried out at Wigan on the steam coals from South Lancashire and Cheshire.

The question of using fuel oil was being discussed in the department in 1865, and Lloyd was associated with the experiments carried out by Captain Selwyn at Woolwich 1866-7, but as is generally known, the use of oil fuel was not adopted in the Navy till nearly forty years later.

Training of Boys

Lloyd took a keen interest in the training of the Engineer Boys, and in 1847 it was arranged that their time at Woolwich would include three days of the week "acquiring theoretical knowledge to fit them for the profession of engineers." He objected to placing these youths in the Fitting Shop of the Factory to obtain their practical experience, on the grounds that the efficiency of the Establishment might to a certain extent be compromised. "The importance, however, of making these lads efficient engineers," he regarded as being so great that arrangements were made to fit up a temporary shop containing "a few footlathes, forges, &c., and to appoint two or three mechanics for their instruction as to the use of such tools as they may have to use hereafter." It was during Lloyd's time at the Admiralty that the ratings of Engine Room Artificer and Chief Stoker were introduced.

Captain Ellice retired in 1850 and Lloyd became Chief Engineer and Inspector of Machinery attached to the Surveyor of the Navy's department at Somerset House. The title of Surveyor was later changed to Controller and in 1860 Lloyd became Engineer-in-Chief of the Navy.

In 1852, accompanied by Whitworth, Penn and the Chief Constructor, Watts, Lloyd paid a visit to the French arsenals and took the opportunity of studying the progress of steam machinery in the French Navy. It has been said that several changes which were introduced into H.M.S. "Agamemnon" were the result of this visit. The "Agamemnon" was the first line-of-battleship designed as a screw ship, and was later employed in assisting with the laying of the first transatlantic cable. Lloyd's advice was sought regarding the design of the machinery for paying out the cable, and his valuable services were afterwards acknowledged by the Atlantic Telegraph Company.

In 1856 he again visited France, this time accompanied by Rear-Admiral Sir Baldwin Wake-Walker, the Surveyor of the Navy, and the Chief Constructor, to witness the effect of artillery on a ship's side protected by shot placed in an external casing. Lloyd suggested that better protection would be obtained by solid iron plates—an idea which was soon accepted by both navies. This proposal was by no means new, but its general adoption appears to date from the time of this second visit to the Continent.

During the last few years of Lloyd's career, we find trials being carried out with compound engines in H.M. Ships. Unfortunately, the Navy's early experience with these engines showed them to be complicated, difficult to handle and unreliable. This probably accounts for the slow adoption of this type of engine in the Service, which in turn delayed the change to higher steam pressures. From 1849 to 1869, boiler steam pressures only rose about 20 lb per square inch.

Lloyd's fifty years of service may be said to cover the transition period from sail to steam, and it very nearly covers the change from wooden to iron hulls. He was serving his apprenticeship when H.M.S. "Comet," the first naval steam vessel, was launched at Deptford, and in 1869, the year of his retirement, the keel plate of H.M.S. "Devastation," the so-called "mastless" turret ship, was being laid. His interest in the performance of propellers never ceased and in the same year trials were being run between H.M.S. "Druid" and H.M.S. "Cadmus," fitted with a Griffiths and a Vansittart screw, respectively.

In acknowledgement of his services, he was made a Companion of the Bath in 1868, and on his retirement, the Controller of the Navy, Vice-Admiral Sir R. Spencer Robinson, wrote :—

"There is no public servant, within my knowledge, who has so largely contributed to the advance of practical science in his particular department.

"To Mr. Lloyd, more than anyone else, is due the successful application of the screw to the propulsion of steamships, and it was owing to his enlightened knowledge and his zealous exertions that the Royal Navy was enabled to take the lead in its application to ships of war.

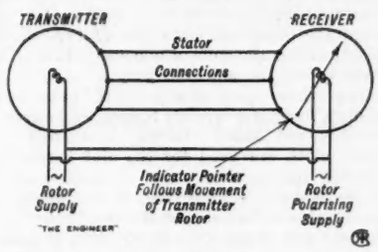
"During a very long public life, Mr. Lloyd has been distinguished for wise and carefully considered suggestions, for improvement of the detail of marine engines; and I venture to say that the principal marine engine makers in this kingdom have frequently consulted him and always benefited by his advice."

Lloyd remained a bachelor, and died at his home at 84, Finchley Road, Hampstead, on March 23, 1875.

Magslip Transmission

THERE are a number of electrical remote indication systems, using the principle of synchronous transmission, whereby it is possible to reproduce accurately the orientation and angular movement of a given object at a remote point. One of these systems, known as Magslip Transmission, was developed by the Admiralty and has been used for a number of years as an essential link in Naval fire control equipment. Before long, Magslip transmission found similar applications in A.A. fire control, and subsequently in radar and direction-finding. Recently it has been decided that Magslip equipment, hitherto exclusive to the Services, may now be manufactured (subject to Admiralty inspection and control) for general industrial use.

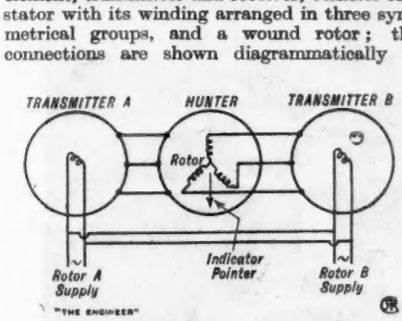
The purpose of this article, therefore, is to outline very briefly the principles of Magslip transmission and to describe some interesting aspects of its production under wartime conditions, when the rapidly increasing demand for Magslip equipment placed a severe strain on the manufacturing resources of those firms who were engaged in producing this apparatus.



TWO-ELEMENT SYSTEM FOR REMOTE INDICATION

Principles of Magslip Transmission

When used as a remote indicator, in its simplest form, the Magslip system comprises two elements, a transmitter and a receiver, each of which is electrically similar to a synchronous motor or rotary transformer. Each element, transmitter and receiver, consists of a stator with its winding arranged in three symmetrical groups, and a wound rotor; the connections are shown diagrammatically in the accompanying illustration. The two rotors are fed from a single-phase a.c. supply, and the resulting synchronous system has the characteristic that, for any angular alignment of the transmitter rotor with respect to its stator, the receiver rotor must take up a corresponding unique alignment. Any subsequent rotation of the transmitter rotor will result instantaneously in an equal rotation of the receiver rotor in the same sense. A pointer fixed to the receiver rotor will therefore give a precise indication of any angular movement of the transmitter rotor. As many as five separate receivers can be operated simultaneously by a single transmitter. It is evident that the inherent accuracy of the system can be effectively magnified by duplicating the arrangement described above, *i.e.*, by having two transmitters with their rotors so geared that they transmit "coarse" and "fine" movements, respectively, while the corresponding "coarse" and "fine" indications are given on the two receivers.



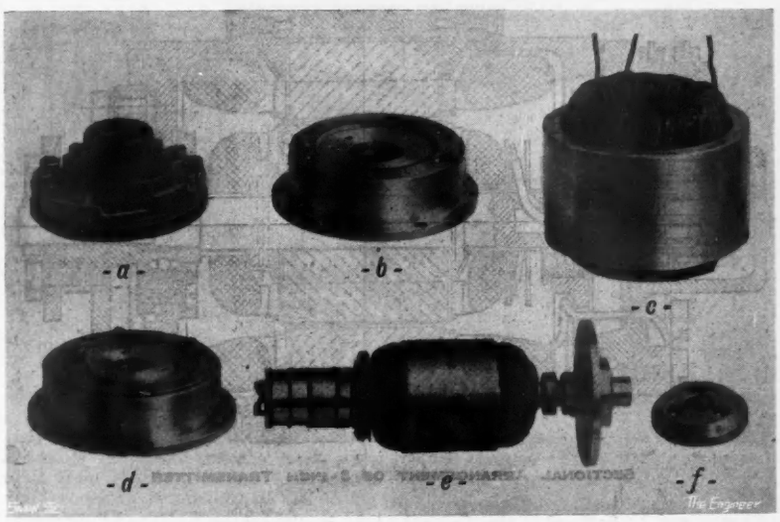
THREE-ELEMENT SYSTEM FOR REMOTE INDICATION OF MISALIGNMENT

A variation of the first arrangement is the "three-element chain," which is illustrated herewith. The two transmitters A and B are identical; the third element, known as a "hunter," has symmetrical three-group windings on both stator and rotor. With the connections shown in the diagram, as long as the transmitter rotors are in alignment, the pointer fixed to the hunter rotor remains in the neutral position. Any misalignment of the rotors A and B results in an equal misalignment of the resultant magnetic fields associated with the stator and rotor of the hunter. The rotor must therefore move until the two resultant fields coincide, so that the angular movement of the hunter and its indicating pointer is an exact measure of the misalignment between the two transmitters. An arrangement such as this has been used in naval gunnery training for indicating errors in laying.

By introducing a servo link between the hunter and the transmitter B, the three-element system described above can be applied to the remote control of a mechanism such as a gun mounting. In this arrangement any misalignment between the control element (geared to the rotor A) and the gun mounting (geared to the rotor B) results in movement of the hunter rotor, which actuates the pilot valve of an hydraulic servo drive. This servo drive then rotates the gun mounting (and with it, the rotor B) until correct alignment is restored, when the hunter rotor and pilot valve return to their neutral position, stopping the drive to the gun mounting.

With the increased application of electrical power to the gun mounting, a system was developed whereby the electrical signal from a Magslip chain could be used directly to control the output of a metadyne set. The accompanying illustration shows, diagrammatically, a Magslip transmitter with its rotor winding supplied from a 1000-cycle a.c. mains and its stator winding connected to the stator of a similar instrument (geared to the gun). The rotor winding of this second instrument is connected through an amplifier and rectifier to the control winding of the metadyne. With the transmitter and mounting in alignment, no voltage is induced in the rotor of the second instrument, and consequently there is no output from the metadyne. When the transmitter is set to some new position a voltage appears at the rotor of the second instrument (proportional to the sine of the angle) and the metadyne output drives the mounting round until the Magslips are once again in "coincidence."

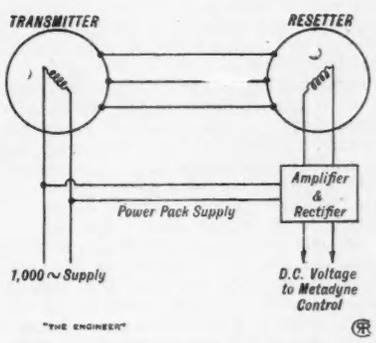
The rectifier is arranged to be "phase selective," so that the polarity of the control voltage to the metadyne and therefore the direction of rotation of the mounting is dependent upon the sense, clockwise or anti-clockwise, of the Magslip misalignment.



(*a*) Terminal carrier, showing five terminal segments and two brush connectors in position.
(*b*) Terminal end cover, showing three holes for stator leads.
(*c*) Wound stator, showing three terminal leads.
(*d*) Spindle end cover, showing lining-up adjuster ring with clamp plate and lining-up bush.
(*e*) Wound rotor, showing slip rings, ball race and rotor washer at one end.
(*f*) Clamp hub, for fixing on rotor hub.

3-INCH TRANSMITTER

An extremely important feature of Magslip systems is the ease with which angular movements can be added to or subtracted from the chain electrically. A "follow through" instrument electrically similar to the hunter described above is connected into the stator leads of a Magslip chain, operating usually at 1000 cycles. Angular movements given to this instrument are added into the chain. This is precisely analogous to the addition of angular motions by a mechanical differential. Typical applications to gunnery work would be the addition into a chain, of signals compensating for target speed, ship's roll, shell drift, &c.



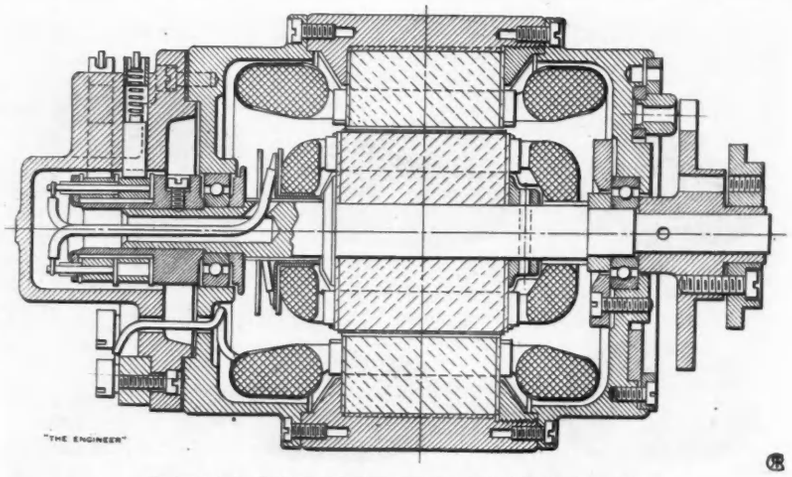
TWO-ELEMENT SYSTEM FOR REMOTE CONTROL

It is evident that these and other variations of Magslip transmission are capable of being widely applied for remote indication as well

as remote control of the alignment of any mechanism.

Wartime Production Difficulties

During the early stages of the war, the demand for Magslip transmission equipment by the Services on land, sea and air increased enormously. These demands involved the manufacture in very large numbers of some 40 different types and sizes of Magslip elements —transmitters, receivers and hunters. Although production from the normal sources of supply increased steadily, it continued to be outstripped by the urgent needs of the moment. By the middle of 1941 the shortage was becoming acute and in September the General Electric Company, Ltd., undertook to equip, manage and operate on behalf of the Admiralty a factory for the production of Magslip elements, at the rate of 200 Magslips per month, by March 15, 1942, increasing to 2500 Magslips per month by June 15, 1942.



Sectional Arrangement of 3-inch Transmitter

The factory selected for this purpose was the Park Vale Works, a Leicester shoe factory. Before the factory could commence operations in its new role, 600 tons of shoe-making machinery had to be removed and replaced by new machinery, and new power and lighting services, including a sub-station, had to be installed. While this work was in progress green labour was being recruited and trained for the many operations involved in the production of Magslips—which combine the appearance of a fractional horsepower motor with the performance of a precision instrument.

From the outset, it was apparent that large-scale production at the Park Vale Works could not be attempted without some modification to the machines initially available. Although the machine shop contained a small number of capstan lathes, productivity was mainly dependent on, and limited by, the output of a large number of 3in centre lathes. Special fixtures and multi-tool heads were, therefore, made up so that, for example, eight cuts could be made in a single operation.

The enforced use of "green" labour presented another problem which applied particularly to the winding shop where more than 75 per cent of the operators, when production commenced, were newcomers to the job of coil winding. To overcome this difficulty, a winding school was established in the works to deal initially with 60 trainees. Later the winding school was turned over to production, which proceeded hand-in-hand with the training of new green labour.

Some measure of the success attending the new venture can be gleaned from the fact that the output attained by March, 1942, was more than three times the number of Magslips called for in the initial programme, while the demand for 2500 Magslips by mid-June was anticipated by one month. Later, increasing demands were made on the factory and by 1943 a peak output of 8000 Magslip units of 34 different types was achieved.

These results were due in a large measure to the successful application of the manufacturing technique normally associated with the production of fractional horsepower motors —a complete departure from the conventional methods whereby each individual Magslip was "tailor-made." However, the newer methods of quantity production could not be applied to the manufacture of Magslips without certain refinements to ensure a standard of quality that would be superfluous in an electric motor but was indispensable in a precision instrument. Many of these refinements are concerned with the processes of coil winding and testing and may perhaps best be illustrated by a brief reference to a typical Magslip unit.

An accompanying engraving shows the main assemblies and components (excluding only the fixing screws, brushes and springs) of a 3in transmitter. Another illustration shows the sectional arrangement of the complete instrument and indicates the method used to bring out the leads from the stator and rotor windings. In this particular instrument the rotor is slotted for a distributed single-phase winding. The stator is built up of circular laminations slotted to receive a distributed three-part winding.

Prior to assembly at the Park Vale Works, the slotted stator stampings are graded according to size to ensure accuracy of the very narrow air gap. Grading is carried out by stacking the stampings on seven mandrels, the diameters of which vary in steps of 0·0005in above and below the plan dimension.

After the graded stampings have been assembled in the stator shell, but before the stator is wound, the components are subjected to two important tests. First, the unwound stator core is tested for magnetic symmetry by fitting it over a test rotor mounted on a plinth. One winding of the rotor is excited from a 1000-cycle supply and the other winding, which is exactly at right angles, is connected to a milli-voltmeter. With a perfect stator there would be no voltage induced in the latter winding, but distortions of the magnetic field give readings on the voltmeter which indicate the lack of symmetry of the stator. Secondly, the former wound stator coils are tested for accuracy of turns. The coil to be tested is slipped over an iron limb carrying an alternating magnetic flux and the voltage induced in the coil is compared with the voltage from a similar coil which is known to be standard. This test will detect an error of one turn in a coil of 200 turns.

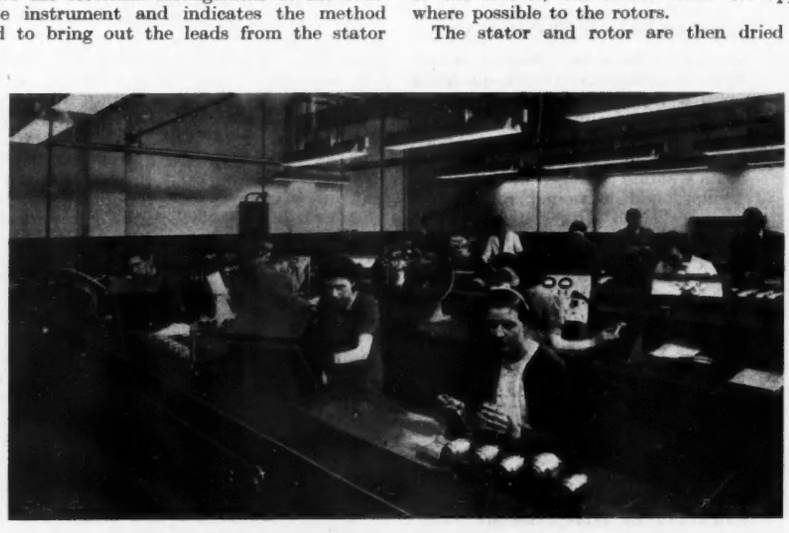
In most cases it is important that the phase resistances of the magslip stator should agree to within 1 per cent. Since variations in the resistances of the individual coils are greater than this, the coils are graded in groups, so that the variation within a group is less than 1 per cent. This is done conveniently on a special resistance bridge, which is set at the nominal value and indicates on a galvanometer the percentage departure from the nominal value. For one stator the coils of one size would all be selected from the same category.

After these preliminary tests have been satisfied, the stator is ready to receive the graded former-wound coils; usually leatheroid and empire cloth are used for the slot insulation.

Before impregnating, the completed stator undergoes further tests such as the check for the impedance balance of the windings. The two adjacent phases of a stator form the arms of an impedance bridge which are balanced against resistances at 1000 cycles. Winding faults such as reversed coils, pitch errors, shorted turns, &c., can be found this way; the greatest sensitivity would be, say, the detection of one shorted turn round two slots. Insulation tests and a test for phase sequence are applied at this stage.

The tests outlined above refer particularly to the stators, but similar tests are applied where possible to the rotors.

The stator and rotor are then dried and vacuum impregnated, after which the silver slip rings are turned, the rotor is balanced, and the instrument is assembled.



Main Testing Department

A general view of the test room at the Park Vale Works is given in the accompanying engraving. Here the final tests are carried out. The acceptance test for a complete Magslip consists in principle of ensuring symmetry of the windings and of the magnetic path, so that the axis of a magnetic field coincides with the axis of the windings producing it. In a perfectly accurate instrument each angular position of the energised rotor would correspond to a certain known distribution of voltage in the three phases of the stator

winding. Any departure from exact symmetry would be reflected in a change in the anticipated stator voltage distribution. By applying this principle, instrument "error" is determined for a number of orientations of the rotor, the results are plotted, and the lining up position of the stator can be adjusted to give the best balance between the "plus" and "minus" errors of the instrument. To pass the acceptance test the error for any orientation of the rotor must not exceed $\pm 0 \cdot 15$ deg. in the typical case of a 3in transmitter.

Special process tests have been adopted at times for special Magslips. One particular instrument developed during the war was incorporated in the H_2S device for blind bombing through cloud. The problem here was to produce instruments within close limits of inductance and effective resistance as measured on the rotor. It was found necessary to select components before winding, and an a.c. bridge was designed for use in the winding shop. A cathode-ray oscillograph was used as a phase-sensitive detector and the bridge could be balanced with two easy adjustments. Components rejected as being unsuitable for this particular application were used for other classes of Magslips, in which a less exacting standard was permissible.

An Automatic Clutch for Presses

In the course of a recent visit to the Sheffield works of the well-known firm of cutlery and file-making machine designers and manufacturers, Walters and Dobson, Ltd., we were shown an interesting automatic clutch which has been developed for use on power presses. This new clutch incorporates a number of safety features, and its design is such that it can readily be adapted to other types of machines in which intermittent or continuous motion with complete and instantaneous disengagement from the drive at the end of a stroke is required.

The arrangement of the clutch mechanism and its striker actuating gear can be seen in the accompanying diagram. A combined flywheel and driving pulley A freely rotates on roller bearings on the main shaft of the machine. Rigidly bolted to the boss of the flywheel is the driving member B of the clutch. The driven member C of the clutch, which is slidably mounted and keyed to an extension of the shaft, is designed to engage the pulley through two dog teeth machined on opposite sides of its face. The use of two opposing dogs balances the driving load and avoids uneven thrust when the clutch is engaged.

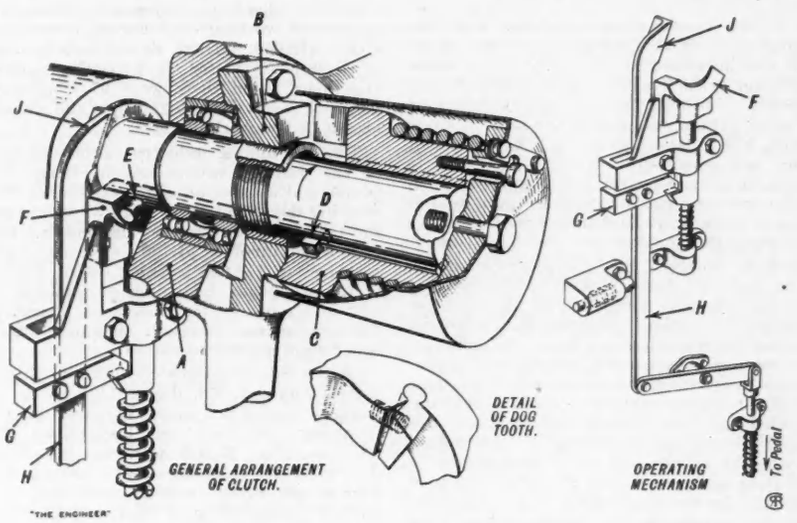
The driven member is spring loaded towards the engaged position but is held out by a head D formed on the clutch actuating rod. This rod slides in a continuation of the keyway cut in the shaft, and at its inner end is a roller E, which is arranged to ride up the sloping cam face formed on the side of the striker mechanism stop F. It will be seen that downward movement of the stop releases the rod, which is forced inwards by the spring pressure on the driven member of the clutch. The two pairs of dogs of the clutch members then engage to rotate the shaft. As rotation begins, the stop returns to its normal operative position against the shaft. Towards the end of the revolution the roller E on the actuating rod begins to ride up the sloping face of the stop and eventually, at the completion of the movement, pushes the driven member of the clutch out of engagement.

The operating mechanism has been designed to give positive control with quick and easy means of changing over from single cycle to continuous drive through the clutch. A spring returns stop F to engaged roller E. To engage the clutch the stop is retracted by means of the latch G on the main lever H of the striker gear. This lever is extended upwards and inwards to form the inclined pad J, which, with the clutch disengaged, has its lower end pressing against the side of the main shaft above the stop.

When the clutch is set for single-cycle operation and the striker pedal is depressed the latch G draws the stop downwards to permit the clutch to engage. As the lever descends it is pushed outwards by the action of the pad J moving over the curvature of the shaft. This outwards movement of the latch disengages it from the stop after a short distance, and the stop returns to its operative position against the shaft to throw the clutch out at the completion of the revolution. By this arrangement, even if the striker pedal is kept depressed, there is no danger that the drive will continue, as each working revolution of the shaft can only be initiated by an individual withdrawal of the stop, and the only way to engage the stop is by complete release of the pedal.

To set the mechanism for continuous drive whilst the pedal is depressed, the position of the latch G on the lever H is easily and quickly altered to put the pad J in an inoperative position with the latch in continuous engagement with the stop.

Another point in the design of the clutch is the large amount of clearance which is permissible between the dogs of the driving and the driven members in the disengaged position. This feature eliminates the necessity for fine setting and the danger of accidental engagement when the flywheel is loosely mounted on its bearings. The means by which this is effected can be seen in the small inset in the diagram. A spring-loaded tooth is mounted on one dog face of the driven member of the clutch and when it is disengaged the top of the outer or working faces are held an appreciable distance clear of their working position. When the clutch is engaged this spring-loaded tooth is pressed back to present a full working area against the dog of the driving member, similarly to the second plain dog.



AUTOMATIC CLUTCH FOR PRESSES

Jet Engines for Snow Clearance

During the recent period of exceptionally severe weather in Great Britain, a new use was found for the Rolls-Royce "Derwent" jet engine. As the accompanying engraving shows, two of these engines were mounted on a railway wagon, at an inclined angle, and were used for blowing away drifts of snow on blocked railway lines. The fuel tank and general arrangement of the engines and their controls will be clearly seen. The experiments were carried out by engineers of the London, Midland and Scottish Railway Company, with the assistance of Rolls-Royce engineers and officers of the Royal Air Force. In addition to this development the Rolls-Royce company has adapted the combustion chambers of its jet engines for burning oil fuel under steam boilers, and the system has been adopted in its works and those of associated companies.

ARRANGEMENT OF JET ENGINES FOR CLEARING SNOW

Industrial and Labour Notes

Britain and International Business

In a statement circulated with the annual report of Telephone and General Trust, Ltd., the Chairman, Sir Alexander Roger, refers to Britain as the "nerve centre of international business." He observes that if Britain possessed sufficient natural resources to be a self-contained nation, like Russia and the U.S.A., neither of which are essentially dependent on exports and imports, the Government could go on turning business and industry upside down, as it is doing at present, without the world doing more than shrug its shoulders.

Britain, however, Sir Alexander comments, while lacking these natural resources, yet remains the real nerve centre of the most complex international business and industrial machine the world has ever seen. Its mobilised and successful experience, ability and knowledge of international business, banking, finance, insurance, transport and trading is still unequalled, and to discard or interrupt this wonderful machine for political and ideological reasons, or to proclaim that the machine is inefficient or incompetent, is nothing short of suicidal. In Sir Alexander's view, it has the most serious adverse repercussions all over the globe on our trade, our prestige and our foreign commercial influence.

The Unemployment Fund

The fourteenth annual report of the Unemployment Insurance Statutory Committee was published last week (H.M. Stationery Office, price 2d.). It covers the year 1946 and is, as usual, divided into two sections, one dealing with the general account and the other with the agricultural account of the Unemployment Fund.

Dealing with the general account, the report shows that receipts for the calendar year 1946 were £97,877,830, the major portion of which sum represented insurance contributions by employers, employed persons and the State. These contributions, it may be remarked, were £4,145,606 in excess of those paid in 1945, as the number of insured persons increased during 1946 by about 1,250,000. The year's expenditure totalled £29,290,179, of which £23,537,000 was paid in unemployment benefit, and including the balance carried forward from 1945, there was at the end of 1946 a net balance of £431,101,303.

The report explains that, apart from the slight increase in unemployment during 1946, some addition to the liabilities of the fund was caused by new regulations whereby additional days of unemployment benefit may be paid after the statutory period has been exhausted. The report also comments that there was some increase in registered unemployment during the first half of 1946, though it was never very considerable. The number of insured persons registered as unemployed rose from 285,000 in December, 1945, to 372,000 in March, 1946, and reached 376,000 in June. The subsequent trend was slightly downward, and in December, 1946, the number was 363,000, despite the normal seasonal unemployment increases of winter-time. It is pointed out, however, that for 1947 it is now clear that the increase to be expected in the average of unemployment as a consequence of the coal shortage may be substantial.

Trade Disputes

The latest issue of the *Ministry of Labour Gazette* records that there were 144 industrial disputes leading to stoppages of work reported as beginning in January in the United Kingdom. In addition, ten stoppages which had begun earlier were still in progress during that month. These 154 stoppages of work involved, during January, approximately 112,000 people, which number included those thrown out of work at establishments where the disputes occurred. The number of working days lost as a result was about 412,000. These figures are in excess of those recorded for the preceding month of December, when there were 97 stoppages in progress, involving 18,700 people and causing a loss of 50,000 working days.

The coal-mining industry accounted for 76 of the January stoppages, involving 13,200 people and causing an aggregate loss of 21,000 working days, and there were 37 stoppages in the metal engineering and shipbuilding industries which involved 51,700 people and resulted in a loss of 118,000 working days. Fourteen of the stoppages beginning in January arose out of demands for increased wages, and 44 were caused through disputes affecting other wage questions.

Of the 137 stoppages of work, which ended during January, 59, directly involving 5100 workers, lasted not more than one day; 34, involving 3900 workers, lasted two days; 13, involving 27,800 workers, lasted three days; 18, involving 2800 workers, lasted four to six days; and 13, involving 15,400 workers, lasted for more than six days.

Mine Mechanisation

The urgency of coal-mine mechanisation is constantly stressed at the present time, and a recent development of the matter is a conference between representatives of the National Union of Mineworkers and the Confederation of Shipbuilding and Engineering Unions, which took place last week. An official statement issued subsequently records that the conference agreed that every effort would be made to provide the mining industry with the machinery and equipment necessary to obtain the coal output required during the present year.

The executive of the National Union of Mineworkers met on Wednesday of last week and discussed a suggestion that there should be an immediate examination of proposals for modernising the coal industry, having particular regard to the production of equipment and machinery.

It is reported that the executive also considered proposals for improving conditions in the mines, increasing coal output, and attracting more manpower. These proposals include a revised wage structure to come into operation at the beginning of next year; the introduction of a pension scheme, and relaxation of the existing Control of Engagement Order so that potential recruits to the mines will not feel that they are to be tied to the industry.

Union Negotiating Machinery

It will be recalled that early in the year the Prime Minister said in Parliament that the adequacy of the existing arrangements for the determination of claims relating to conditions of employment and the settlement of industrial disputes was being examined by the Government.

The Trades Union Congress has recently stated that, following an informal talk with the Minister of Labour, the general council has been considering the possibility of measures to speed up negotiating machinery. It is well known that unofficial strikes owing to delay in negotiating procedure have given concern to the Government, which is anxious, however, that nothing should be done to weaken the authority of the unions. The T.U.C. points out that the machinery for the settlement of trade disputes is broadly of two kinds—statutory machinery and voluntary joint machinery, so that any alteration of the procedure of statutory bodies would involve legislative or administrative action on the part of the Government. In the case of voluntary negotiation, of course, it is principally and ultimately a matter to be determined by the unions and the employers concerned. The T.U.C. general council proposes to discuss, with the Government, the matter of statutory negotiating machinery, after consultation with the unions concerned, but it is unlikely that it will wish to discuss in any detail with the Government the procedure of voluntary joint bodies. It is still less likely that the T.U.C. will ever wish to invite the Government itself to take any action in respect of the voluntary negotiating bodies.

The T.U.C. says that its general council is aware that criticisms of delay in the settlement of trade disputes are more frequently directed against statutory bodies than against voluntary bodies. Moreover, workpeople often complain of delay in reaching a decision when, in fact, their real disappointment is with the decision itself. Nevertheless, it is admitted that criticism is not exclusively of statutory bodies and that the existing procedure of some voluntary bodies could be speeded up. The T.U.C. general council is therefore suggesting that unions should give consideration to the matter and to ways in which the speeding up could be achieved in the various industries with which unions are concerned.

Buying Prices for Tin

Following the announcement last week of increased selling prices for tin metal, the Ministry of Supply has now stated that new buying prices became effective on April 2nd for Malayan tin metal and Nigerian tin concentrates. The buying price for Malayan tin metal has been advanced from £370 to £423 a ton at smelters' works, and that of Nigerian concentrates has been advanced from £357 10s. to £405 15s. per ton of tin in ore, f.a.s. Nigerian port. The selling price of Malayan tin metal has been increased to £426.

The Year's Coal Target

At a press conference on the nation's economic situation on Wednesday of last week, the President of the Board of Trade, Sir Stafford Cripps, commented on the suggestions made recently by the Federation of British Industries and the Trades Union Congress that this year's coal target should be higher than the 200,000,000 tons set out in the Economic Survey. He said that the target was neither an optimum assessment nor an expression of needs, but was an estimate of what, at the date of the White Paper, it was fair to expect. The Government would like to see 300,000,000 tons of coal produced and, Sir Stafford added, "the nearer we get to that the better we shall be pleased."

Dealing with recruitment for the mines, Sir Stafford said that the total number of men employed on March 22nd was 705,640, which was an increase of almost 14,000 since the beginning of the year. Nearly half of them were ex-miners returning to the pits from other industries. The number of boys entering the coal mining industry was approximately double what it had been last year, although the raising of the school-leaving age would result in a falling-off for a year at least. Coal production, Sir Stafford continued, was also increasing, and in the week ended March 29th exceeded 4,000,000 tons. It was hoped to improve the coal allocation to industry very shortly, and to this end a new scheme was being worked out for the summer period.

Another matter which Sir Stafford mentioned was that a review of generating plant—production of which it was hoped could be speeded up—and of railway trucks and locomotives had been made, and the export programme was undergoing review to see if anything useful could be done to help the home situation.

French Engineering News

(From our French Correspondent)

PARIS, April 4th

In order to improve communication by water between the Lille-Roubaix-Tourcoing area and Dunkirk, important work on the canal linking the area with the centre of the *département* has been undertaken, and is nearing completion. The locks on the canal, except for that at Cuinchy, were only 1·8 m to 2 m deep, and would only permit the passage of 280-ton canal boats. The work undertaken includes dredging to 2·8 m depth, enlarging the locks, and improvement of the waterway to enable large lighters to pass. The scheme was scheduled to take five years, but the time promises to be considerably reduced, two locks being constructed a year instead of one. At the moment 280-ton barges take a week to proceed from Dunkirk to Lille and another two days to get to Roubaix. When the work has been completed, double the traffic will be carried, loads will be twice as heavy, and the time will be cut by over half. First of the important works undertaken was at Dunkirk, at the mouth of the Bourbourg Canal. The lock was destroyed in 1944, but even before the war there had been plans to replace it. The whole of the work is now planned to be completed by 1950. Widening the canal, straightening curves, and deepening the bed will be carried out simultaneously with the construction of the locks. The Monnet Plan also envisages the construction of a lock to duplicate the Fontinettes ship-canal lock, which will be one of the most important in Europe.

* * *

Total imports of coal by France in 1946 amounted to 10,500,000 tons, compared with 31 million tons in 1937. Major differences were the drop in imports from England from 9,328,000 tons to 730,000 tons, and 2,100,000 tons compared with 11,485,000 tons from the Ruhr. On the other hand, the U.S. supplied 5,200,000 tons, against nil in 1937, and the Saar 1,300,000 tons, against nil. While awaiting the modernisation of her own mining equipment, which will take about ten years, France depends largely on imports for the recovery of her industry. National production is expected to be 55 million tons in 1947, of which 11,500,000 tons will go to thermal plants to supply 12 milliard kWh of electricity. About 25,000,000 tons more will have to be found to satisfy indispensable industrial and domestic needs. Even in 1950, when the first part of the programme has been completed, France will be short of about 20,000,000 tons.

It is hoped that imports for 1947 will amount to 18,500,000 tons, but this is considered unlikely unless more is forthcoming from the Ruhr and Saar. In addition, the question of manpower is becoming crucial with the imminent repatriation of 25,000 Polish miners and the liberation of German prisoners of war. Prospection and experimental mining in the French colonies will cost two milliard francs over the next ten years. Owing to a demand for electricity, a plant is to be constructed on the Ivory Coast, to produce 50 million kWh, using sea-power.

* * *

In 1946 96,122 vehicles were produced by the French automobile industry, including 30,428 private cars, 16,695 lorries of under two tons, 45,877 lorries over two tons, 2646 cars and 495 tractors. Total tonnage is less than 63 per cent of 1938 production, due mainly to the fact that the industry received only 6 per cent of the available ferrous metal. Unless larger allocations are made in 1947, France will find it difficult to face foreign competition.

Out of the 200,000 tractors required, 180,000 still remain to be supplied. For the past three months, the steel industry, suffering from lack of coke, has only been working at 60 per cent of capacity. Out of 159 blast furnaces, only 57 are working, and out of 117 Martin ovens, only 62 are active. Until the steel output can be increased, constructors are unable to produce the required tractors.

Notes and Memoranda

Rail and Road

OIL-BURNING LOCOMOTIVES.—The Minister of Transport was questioned in Parliament last week about the cost and time taken to convert locomotives from coal to oil-firing. In reply, he said that the best estimate possible at present of the cost of conversion, including the cost of installations at storage depots, was about £1850 per locomotive converted. The actual work of conversion of an engine took about ten days, but the Minister pointed out that engines could not be converted until the necessary storage depots were available.

TOLL BRIDGES AND ROADS.—The Minister of Transport is asking highway authorities to co-operate with him in a new drive to free toll roads and bridges, and is taking steps to eliminate toll bridges and roads on trunk roads, for which he is responsible. In a letter to highway authorities, the Minister points out that the elimination of tolls is a form of highway improvement which can well be undertaken at the present time, as it involves little or no labour or materials, but can increase considerably the convenience of communication. One of the toll bridges on trunk roads, at Dornie, Ross and Cromarty, was freed recently. There remain four bridges subject to toll on trunk roads, at Conway, Selby, Durham, and Old Shoreham, and there is one length of trunk road subject to toll, the Port Madoc-Minffordd embankment, between Caernarvon and Merionethshire. In England, Scotland and Wales there are, in all, fifty-eight toll bridges and forty-one lengths of road subject to toll. The Minister is generally prepared to make grants for freeing the roads and bridges at the normal rates of 75, 60 or 50 per cent, according to the classification. Highway authorities are asked to submit proposals to the Ministry's Divisional Road Engineer for their area.

Air and Water

SWEDEN'S SAILING SHIPS.—The annual report of the Swedish Sailing Ships Association shows that in 1946 the Association's fleet consisted of 949 auxiliary sailing vessels, aggregating 86,991 gross tons.

YELLOW RIVER DYKE BREACH.—According to a statement issued by the Chinese National Conservancy Commission, the eight-mile breach of the dykes along the Yellow River at Hwayuankow was closed on March 15th.

NEW B.O.A.C. APPOINTMENTS.—In the House of Lords last week, Lord Nathan, the Minister of Civil Aviation, announced that Sir Harold Hartley, F.R.S., had been appointed Chairman of British Overseas Airways Corporation. Mr. Whitney Straight has been appointed managing director (chief executive) and Major J. R. McCrindle, managing director (external affairs).

U.S. AND GERMAN SHIPS.—The Minister of Transport states in a recent written reply that the United States Government has agreed to the sale to United Kingdom shipowners of 106 "Liberty" ships and one smaller vessel and the sale of thirty short sea vessels to the British Government. The same reply adds that the British Government has received eighty-nine ships, aggregating 350,000 gross tons, as reparations from Germany.

Miscellanea

KRAFT PAPER BAGS.—The National Council of Building Material Producers has issued an appeal, originating from the Minister of Works, for the utmost economy in the use of Kraft paper bags, the shortage of which is imperilling the distribution of cement and similar powdered products. A world shortage of Kraft pulp makes salvage a vital matter, and manufacturers and distributors are asked to organise a steady flow of used bags back to the mills.

METAL FINISHING STANDARDS.—A handbook of "Electroplating and Metal Finishing Standards," published by the Metal Finishing Association, summarises the system of standards adopted in recent years. The system has been devised to enable a buyer without technical experience of electroplating to order the standard finish which has been proved to stand up to the required service conditions, provided, of course, that the basis metal to be plated is sound. The standards set out are for nickel, chromium, copper, zinc, cadmium, lead and tin finishes. There are also sections dealing with precious metals, heavy deposition, and anodising.

LOW-TEMPERATURE CARBONISATION.—The Parliamentary Secretary to the Ministry of Fuel and Power announced recently that while the present shortage of fuel continued, it was not possible to allocate additional supplies for low-temperature carbonisation. When more coal was available, the question of developing the process would be considered in the light of the demand for its products and the importance of their uses.

RESEARCH AND THE SMALLER FIRM.—Last October, the Manchester Joint Research Council organised a one-day conference to discuss the subject of "Research and the Smaller Firm." The proceedings at this conference have now been published in the form of a small book, which can be obtained for 2s. 6d., plus postage, from the Manchester Joint Research Council, Chamber of Commerce, King Street, Manchester, 2.

SURPLUS MACHINE TOOLS.—The Ministry of Supply is conducting a campaign to bring to the notice of the small men in industry that 40,000 surplus machine tools are available for purchase. The Ministry has already disposed of over 110,000 machine tools for £28,000,000, but although large users have had their needs met, many small firms are still requiring machine tools. A press and poster advertising campaign will bring the scheme to this class of purchaser. Advertisements are being published in London and provincial daily and weekly newspapers, and posters will be shown at labour exchanges, town halls and other centres likely to be visited by the small manufacturer and workshop owner.

IRON AND STEEL INSTITUTE.—The Iron and Steel Institute is holding a special Summer Meeting in Switzerland in July. Meetings for the discussion of papers will take place in Zurich on July 10th and 11th, and from then until July 15th visits to works and other places of interest in the vicinity are being arranged. Thereafter, from July 16th to 21st, members and their ladies are invited to take part either in a five-day excursion through Switzerland ending at Geneva, or an excursion to Geneva, with visits to works in the neighbourhood, and concluding with the week-end in Geneva. The Swiss iron and steel and engineering industries are collaborating in the arrangements for the meeting.

THE FILM PRODUCERS GUILD.—Recognition of the value of films as instruments of information, education and persuasion is increasing, and in recent years the demand for films of these kinds has grown enormously. Improved standards of production have to be kept in mind, and the Film Producers Guild, Ltd.—an association of industrial, documentary, educational and propaganda film-producing and distributing companies—has just issued a well illustrated brochure describing its recent achievements and giving details of the facilities available for the preparation, actual making, and distribution of films. The secretary of the Guild is Mr. K. Lockhart Smith, Guild House, Upper St. Martin's Lane, London, W.C.2.

PUBLIC WORKS CONGRESS AND EXHIBITION.—It is announced that arrangements are well advanced for the 11th Public Works, Roads and Transport Congress and Exhibition, which is to be held at Olympia, London, from July 21st to 26th, next. The Congress and Exhibition has not been held since 1937, and it is stated that considerable interest is being shown in their revival. The appointment has already been notified by local authorities of a large number of delegates to the Congress. Papers to be read will cover a wide variety of local government and public works problems, including coast erosion, road safety, new motor roads, public cleansing, sewage disposal and administrative control. Details of these papers will be announced shortly.

SILICOSIS AND DUST SUPPRESSION IN MINES.—The Institution of Mining Engineers and the Institution of Mining and Metallurgy are organising a conference on silicosis, pneumokoniosis, and dust suppression in mines. It will take place on Wednesday and Thursday next, April 16th and 17th, at the Royal Institution, 21, Albemarle Street, London, W.1, beginning at 10.30 a.m. each day. The purpose of the conference is to give all who are concerned with the health and welfare of underground workers an opportunity of discussing the latest information on the nature and prevention of silicosis and pneumokoniosis. The first Sir Julius Wernher memorial lecture of the Institution of Mining and Metallurgy will be delivered by Major-General A. J. Orenstein, M.D., F.R.C.P., on Tuesday evening next, April 15th, at 5.30, also at the Royal Institution. The subject is "The History and Prevention of Silicosis, with special reference to the Witwatersrand."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tuesday, April 15th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Light and Colour as Applied to Works Equipment," W. Robinson. 6.15 p.m.

British Interplanetary Society

Saturday, April 12th.—Science Museum, South Kensington, S.W.7. "Cosmic Rays," Lionel Gilbert. 6 p.m.

Derby Society of Engineers

Monday, April 14th.—School of Arts, Green Lane, Derby. Film, "Contribution to Victory." 7 p.m.

Illuminating Engineering Society

Friday, April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "Portable Photometers," J. S. Preston. 6 p.m.

Institute of Marine Engineers

Tuesday, April 15th.—85, The Minories. E.C.3. "High Creep Strength Austenitic Gas Turbine Forgings," D. A. Oliver and G. T. Harris. 5.30 p.m.

Institute of Refrigeration

Tuesday, April 15th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Construction of Refrigerated Merchant Ships during the War," G. R. Weir. 5.30 p.m.

Institute of Road Transport Engineers, Ltd.

Thursday, April 17th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2. "Fuel Injection Equipment and its Influence on the Performance of Oil-Engined Road Vehicles," H. G. Dunn. 6 p.m.

Institute of Welding

To-day, April 11th.—S. LONDON BRANCH: Institute of Marine Engineers, 85, The Minories, E.C.3. "A Symposium on the Welding of Light Gauge Metals." 7 p.m.

Institution of Civil Engineers

Wednesday April 30th.—N. WESTERN ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester. Annual Dinner. 6.30 p.m.

Institution of Electrical Engineers

To-day, April 11th.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh Luncheon. 12.30 p.m.

Monday, April 14th.—S. MIDLAND CENTRE: Midland Institute, Paradise Street, Birmingham. "The Generation and Wholesale Distribution of Electricity," J. Hacking. 6 p.m.

Tuesday, April 15th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Does Standardisation Conflict with Progress?" 5.30 p.m.

Tuesday, April 22nd.—SCOTTISH CENTRE: The Royal Technical College, George Street, Glasgow. "The Grid System in War ime," J. Hacking and J. D. Peattie. 6.15 p.m.

Wednesday, April 23rd.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "New Possibilities in Speech Transmission," D. Gabor. 5.30 p.m.

Institution of Factory Managers

Wednesday, April 16th.—S.E. LONDON BRANCH: Bonnington Hotel, Southampton Row, W.C.1. "Education for Management," Colonel L. Urwick. 6.45 p.m.

Institution of Mechanical Engineers

Thursday, April 17th.—WESTERN BRANCH: Merchant Venturers' Technical College, Unity Street, Bristol. "Fluid Couplings and their Applications," A. R. Vickers. 7 p.m.

Friday, April 25th.—Storey's Gate, St. James's Park, S.W.1. "Stress Concentration and Fatigue Failures," Professor S. Timoshenko. 5.30 p.m.

Saturday, April 26th.—N. WESTERN GRADUATES: Engineers' Club, Albert Square, Manchester. "Electronics for the Mechanical Engineer," K. M. Fantom. 2.30 p.m.

Institution of Mining and Metallurgy

Tuesday, April 15th.—The Royal Institution, 21, Albemarle Street, W.1. "The History and Prevention of Silicosis with Special Reference to the Witwatersrand," Major-General A. J. Orenstein. 5 p.m.

Institution of Post Office Electrical Engineers

Monday, April 28th.—Faraday Building (South Block), Knightrider Street, E.C.4. "Repeater Station Power Supplies," K. W. Hix. 5 p.m.

Institution of Production Engineers

Wednesday, April 16th.—MANCHESTER SECTION: College of Technology, Manchester. "Broaching Machines, Tools and Practice," E. Percy Edwards. 7.15 p.m.—SHEFFIELD SECTION: Royal Victoria Hotel, Sheffield. "Stainless Steels," Mr. Tupholme. 6.30 p.m.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Developments in Gear Cutting and Finishing Processes," F. J. Everest. 7 p.m.

Thursday, April 17th.—GLASGOW SECTION: Inst. of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. Annual general meeting. 7.30 p.m.—LEICESTER SECTION: College of Technology, Leicester. Annual general meeting. 6.30 p.m.

Monday, April 21st.—HALIFAX SECTION: White Swan Hotel, Halifax. "Engineering Applications of Polarised Light," J. Ward. 7 p.m.

Thursday, April 24th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Managerial Problems," Mr. Griffin. 6.30 p.m.

Friday, April 25th.—LINCOLN SUB-SECTION: Lincoln Technical College, Lincoln. "X-Rays in Industry," J. L. Mullins. 6.30 p.m.

Junior Institution of Engineers

To-day, April 11th.—39, Victoria Street, S.W.1. "Prestressed Reinforced Concrete," C. E. Reynolds. 6.30 p.m.—WESTERN MEMBERS: Merchant Venturers' Technical College, Unity Street, Bristol. Films, "Valley of the Tennessee," "The Town To-day and To-morrow." 7 p.m.

Friday, April 18th.—39, Victoria Street, S.W.1. "Some Notes on Ropes," R. P. Mears. 6.30 p.m.

Monday, April 21st.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. "Steam Locomotives for Express Traffic on the Railways of Great Britain, 1906–46," C. B. Harley. 7 p.m.

Friday, April 25th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Annual Dinner. 6.45 p.m.

Manchester Geological and Mining Society

Tuesday, April 15th.—Engineers' Club, Albert Square, Manchester. "Belt Conveyors," J. H. Plumtre. 3.15 p.m.

Newcomen Society

Wednesday, April 16th.—Science Museum, South Kensington, S.W.7. "Windshafts," Rex Wailes; and "The Wind Mills of Hanover," Capt. D. W. Muggeridge. 5.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, April 18th.—Mining Institute, Newcastle-on-Tyne. "Experiments in the Lithgow Propeller Tunnel," A. Emerson and L. W. Berry. 6 p.m.

Wednesday, April 23rd.—STUDENTS SECTION: Bolbec Hall, Newcastle-upon-Tyne. "Ships' Deck Machinery," W. F. Rogerson. 6.45 p.m.

Monday, April 28th.—Mining Institute, Newcastle-upon-Tyne. "Some Model and Full Scale Experiments on Side Launching," F. H. Todd and E. Laws. 6 p.m.

North Western Fuel Luncheon Club

Wednesday, April 16th.—Engineers' Club, Albert Square, Manchester. "Oil in the Middle East," Sir Frank E. Smith. 12.30 p.m.

Royal Aeronautical Society

Thursday, April 17th.—Inst. of Civil Engineers, Great George Street, S.W.1. "Testing Civil Aircraft," P. A. Hufton. 6.30 p.m.

Thursday, April 24th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Risk of Fire and Fire Prevention Methods," J. W. Drinkwater and W. G. Glendening. 6 p.m.

Royal Statistical Society

To-day, April 11th.—INDUSTRIAL APPLICATION SECTION: E. L. M. A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "Methods of Forecasting and Preventing Accidents," L. T. Wilkins. 6 p.m.

Tuesday, April 15th.—N. EASTERN GROUP (INDUSTRIAL APPLICATIONS SECTION): Lemington Glass Works, Limited, Lemington-on-Tyne. "The Application of Statistical Control to the Quality of Blown Glassware," J. Elliott and W. J. Jennett. 7 p.m.

Sheffield Metallurgical Association

To day, April 11th.—MODERN METHODS OF ANALYSIS GROUP: 198, West Street, Sheffield. "Metallurgical Chromatography," G. Robinson. 7 p.m.

Tuesday, April 15th.—198, West Street, Sheffield. "Origin and Constitution of Certain Non-Metallic Inclusions in Steel," J. L. Rait and H. W. Pinder. 7 p.m.

Tuesday, April 29th.—198, West Street, Sheffield. "Springs for High Duty Purposes," Brinley Jones. 6.30 p.m.

Society of Chemical Industry

Thursday, April 17th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Modern Road Construction in Concrete," W. P. Andrews. 6 p.m.

Society of Engineers

Monday, April 14th.—Geological Society, Burlington House, Piccadilly, W.1. "Research and New Developments in Water Treatment," J. G. Milton. 5 p.m.

Stephenson Locomotive Society

Saturday, April 19th.—N. EASTERN BRANCH: Central Methodist Church Hall, Newcastle-on-Tyne. "The Churchward Locomotives of the G.W.R.," W. A. Tuplin. 2.30 p.m.

Women's Engineering Society

Wednesday, April 16th.—35, Grosvenor Place, S.W.1. Discussion, "Equal Pay," 7 p.m.

Launches and Trial Trips

SALINAS, cargo liner; built by Harland and Wolff, Ltd., for the Pacific Steam Navigation Company, Ltd.; length 467ft, breadth 62ft 6in, depth 30ft 9in; gross tonnage 7000. Engines, double-acting, eight-cylinder, two-cycle; cylinders 620 mm bore by 1400 mm stroke. Launch, March 7th.

MUNSTER, cross-channel passenger vessel; built by Harland and Wolff, Ltd., for the British and Irish Steam Packet Company, Ltd.; length 367ft, breadth 50ft, depth 19ft,; gross tonnage, 4000. Engines, two-trunk type, two-cycle, airless-injection Harland B. and W. diesel, with cylinders 500 mm bore by 900 mm stroke. Launch, March 25th.

Personal and Business

MR. H. M. GIBSON has been elected a director of the Manchester Ship Canal Company.

MR. T. R. NAYLOR, M.A., M.I.M.M., has joined the staff of Dorr-Oliver Company, Ltd.

MR. A. S. MACLELLAN has been appointed Chairman of Alley and MacLellan, Ltd.

MR. T. B. O. KERR has been appointed assistant secretary of the General Electric Company, Ltd.

SIR PERCY MILLS, MR. A. P. H. AITKEN and MR. G. A. PHILLIPS have joined the board of Textile Machinery Makers, Ltd.

ACTICARBON, LTD., 175, Piccadilly, W.1, announces that its name has been changed to The British Ceca Company, Ltd.

MR. A. W. A. DICK-CLELAND has been appointed general manager of the Trafford Park works of Lancashire Dynamo and Crypto, Ltd.

THE HARLAND ENGINEERING COMPANY, LTD., has appointed Mahindra and Mohammed, Ltd., Calcutta and Bombay, as its agents in India.

MR. F. W. HALLIWELL has been elected President, and Mr. H. S. Holden has been elected Chairman of the Gauge and Tool Makers' Association.

THE GREAT WESTERN RAILWAY announces that Mr. A. W. Woodbridge has been appointed signal and telegraph engineer, Reading, on the retirement of Mr. F. H. D. Page.

MR. H. R. HAERLE, A.M.I.Mech.E., has been appointed technical manager, and Mr. D. A. Higgs, A.M.I.Mech.E., engineering sales-manager, of the Hymatic Engineering Company, Ltd.

DR. JAMES M. MCNEILL has been elected President of the Institution of Engineers and Shipbuilders in Scotland. Dr. A. McCance and Professor A. M. Robb have been elected Vice-Presidents.

MR. NORMAN RADLEY has been appointed resident overseas sales and service representative of F. Perkins, Ltd, in the Union of South Africa, Northern and Southern Rhodesia, Kenya, and Portuguese East Africa.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LTD., announces that Mr. Ben Thornton has been appointed assistant to the managing director and that Mr. W. H. Day has been appointed secretary of the company.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY announces the following appointments: Mr. A. L. Owen, assistant to the District Engineer, Bradford, and Mr. R. H. Pigott, works manager, Signal and Telegraph Engineer's department, Irvine.

MR. A. B. MALLINSON, M.I.Mech.E., M.I.E.E., Worsley Street, Salford, 3, states that his consulting practice will in future operate as A. B. Mallinson and Co., the partners being Mr. A. B. Mallinson, Mr. A. C. Mallinson and Mr. R. F. A. Mallinson.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH announces the following appointments: Engineer Vice-Admiral Sir Harold Brown, Chairman of the Fuel Research Board, in succession to Sir Harold Hartley; Sir Stanley Angwin, Chairman of the Radio Research Board, in succession to Sir George Lee.

Contracts

THE METROPOLITAN BOROUGH OF FULHAM has placed a contract for three up-river Thames colliers of about 2500 tons deadweight with the Burntisland Shipbuilding Company, Ltd. Two of these vessels are to be built at the Burntisland yard and one is to be built by its subsidiary company, Hall Russell and Co. Ltd., Aberdeen.

THE FRASER AND CHALMERS ENGINEERING WORKS of The General Electric Company, Ltd., has been awarded a contract, valued at approximately £250,000, for an extensive installation in Bihar Province, India. An entirely new colliery is to be equipped from the level of the coal seam to the despatch of the treated coal. The plant includes a steam power station, bunkers, conveyors, and a "Chance" washer.

DORMAN, LONG AND CO., LTD., is supplying the structural steelwork and other materials for three new power stations, and for extensions to thirteen existing power stations in Great Britain. Many of these extensions, it is stated, are equal to or larger than the existing units and will mean an increase to double or treble the existing capacity. Approximately 35,000 tons of structural steelwork is involved and the total value of the contracts is about £2,000,000. The new power stations are Meaford (Stoke-on-Trent), Staythorpe (Newark), and Birkenhead, and the extensions to power stations include Nottingham, West Ham, Huddersfield, Ferrybridge, Bradford, Stourport, Littlebrook (Kent), Fulham, Thornhill (Dewsbury), Hayle, Earley, Rotherham and Dunston.

A Seven-Day Journal

Technical Mission to the Caribbean

In a Journal note of December 20th last we summarised the findings of a British technical mission, arranged by the Council of British Manufacturers of Petroleum Equipment, which visited the oilfields and refineries in the Caribbean area. On Thursday, April 10th, a conference was called at the Mayfair Hotel, under the chairmanship of Mr. S. T. Robson, to discuss the general report, and members of the mission were present to answer questions. The mission found, it was stated, that in each country visited British goods were favoured, but there were difficulties both in supply and times of delivery. There was no difficulty in meeting American specifications, as those specifications had been chosen as the basis of British designs; but an alternative British specification was now being completed, in conjunction with the British Standards Institution. As an instance it was mentioned that the Punta Cardon refinery, belonging to the Shell Group, although partly American designed, was some 95 per cent British in respect of equipment. There was a demand for drilling and ancillary equipment, but alongside those demands were others for such items as agricultural and road-making machinery, bridge building, water supply, &c. Questions revealed that there were already millions of pounds of oil equipment in the Caribbean area. The mission pointed out that one or two instances of British firms putting price before quality had been discovered, and it was pointed out that such action must be discontinued at once in order to protect the high reputation which British manufacturers had throughout these countries. The Government could also help by reducing formalities, increasing the steel quota and reducing the delay in supplies of raw materials. There was also a great need, the mission stated, for an improvement in the shipping facilities to the Caribbean area. That was a matter, it was stated, which the Ministry of Transport might well consider. A happy feature was the getting together of all manufacturers to bring out a composite catalogue of petroleum equipment, which has now been done, and a copy of the new catalogue was on view. The Council of British Manufacturers of Petroleum Equipment is to be congratulated on the excellence of this volume, which should greatly help British trade.

De Ruyter Gold Medal Awarded to Mr. G. J. Lugt

British friends of Mr. G. J. Lugt, the chief engineer of the oil engine department of Werkspoor, Amsterdam, will learn with pleasure of the recent award to him of the "De Ruyter" Gold Medal, which every five years is given by the De Ruyter Committee and Fund to outstanding workers in the sphere of marine technical knowledge. Vice-Admiral Quant, of the Royal Netherlands Navy, in his citation, said that Mr. Lugt joined the firm of Werkspoor in 1910, the year in which the "Vulcanus," the first ocean-going motorship in the world, engined by Werkspoor, went to sea. He had taken a leading part from the very first in the design and development of the marine oil engine. His first contribution was the Werkspoor reversing gear, which is still used practically unchanged on modern four-stroke engines. He followed that invention with several improvements, all made with a view to rendering the engine more accessible and reliable in sympathy with "the man below." In 1924 he developed, in conjunction with British licensees, the Werkspoor double acting design, which was closely followed by the Werkspoor under-piston, four-stroke supercharging system. The success of that principle is shown by the fact that to-day over 2000 cylinders of that type are in operation. A notable Werkspoor installation. Admiral Quant went on to say, was that for the "Zwarte Zee," the largest, fastest and most powerful ocean-going motor tug yet built. Mr. Lugt's gifts as an inventor, designer and constructor had already been acknowledged both in Holland and England by the presentation of the Gold Medals of the Royal Netherlands Institution of Engineers and of the North-East Coast Institution of Engineers and Shipbuilders. Mr. Lugt had a talent for finding simple solutions to engine design problems, and it was satisfactory to know that his undoubted gifts in that direction had been successfully applied to the design and building of a novel form of marine oil engine, now on the test bed, the completion of which is awaited with the greatest interest.

Industrial Research in Technical Colleges

Some months ago the Federation of British Industries set up a special sub-committee, under the chairmanship of Sir Robert Pickard, to consider the results of a survey on the industrial research activities of Britain's technical colleges and the Ministry of Education's future plans for industrial research in technical colleges. The sub-committee was also asked to report on the possibility of co-operation by industry in this matter. This sub-committee's report has now been published and explains that fifty-seven technical colleges were examined during the survey. More than 300 research workers are engaged on research in technical colleges, about 200 of them being members of the college staffs. Most of the colleges, the report states, have close links with local industry and many are keen to initiate an organised programme of research work where it does not at present exist, although at present they are handicapped by inadequate facilities, equipment and lack of staff. The view is expressed, however, that industry is not sufficiently aware of the research facilities existing in technical colleges or of the assistance that can be provided in the solution of industrial problems and the application of scientific knowledge for the benefit of local industry. Numbers of technical colleges, it is suggested, are capable of pursuing development research for local industry in solving all problems involved in the technical application of the results of fundamental research. It is further suggested that technical colleges should take active steps to maintain contact with industry and keep themselves up to date with current industrial technique and needs. The report also makes some observations on the part that industry can play, and urges that firms should take an increasing interest in technical colleges, not only as places where staff can be trained, but as centres which may be of supplementary assistance to their research activities. Where practical, it is recommended, research scholarships and endowments from industry, as well as grants for and loans of special equipment and plant, should be encouraged.

The Late Lieut.-Col. S. E. Monkhouse

We regret to have to record the death, on Thursday, April 10th, of Lieut.-Col. S. E. Monkhouse, who was until recently managing director of the North-Eastern Electric Supply Company, Ltd. He was sixty-one years of age. Colonel Monkhouse joined the North-Eastern Electric Supply Company, Ltd., in 1904—when it was known as the Newcastle-upon-Tyne Electric Supply Company, Ltd.—and after gaining experience in the operation and construction departments was appointed head of the power department. In 1929 he was appointed chief assistant to the general manager and two years later became assistant general manager. On the death of Mr. H. A. Couves in 1937 Colonel Monkhouse succeeded to the post of general manager, becoming a director of the company in the same year, and in 1939 he was appointed managing director. He retired from that office last September, but retained his seat on the board. In the course of his career Colonel Monkhouse rendered a great deal of valuable service to various associations connected with the electricity supply industry. He was a Past-President of the Incorporated Association of Electric Power Companies, Past-Chairman of the Joint Committee of Electricity Supply Associations, a member of the National Joint Industrial Council of the Electricity Supply Industry and of the Central Electricity Board's National Consultative Committee, and Chairman of the C.E.B. Technical Consultative Committee for North-East England. He was also a member of the Institution of Electrical Engineers and of the North-East Coast Institution of Engineers and Shipbuilders. In the 1914–1918 war Colonel Monkhouse served with the Royal Engineers, and was prominently associated with the development of anti-aircraft defence.

The "Queen Elizabeth" Aground

The Cunard White Star liner "Queen Elizabeth" ran aground on Brambles Bank, near the entrance to Southampton Water, on Monday last, April 14th, as she was completing the return voyage from New York. The liner was scheduled to dock at Southampton at 7.30 p.m. on Monday, but the efforts of seven tugs to free her from the Bank were not then successful, although the hope was expressed that it would be possible to move her at high water on Tuesday morning. The ship was lying on an even keel and the weather was calm. It proved impossible, however, to move the 85,000-ton liner on Tuesday morning's high tide, and oil and fresh water were pumped from her to lighten the load, and baggage and some passengers were taken off later in the day. The "Queen Elizabeth" was eventually refloated at 8.40 p.m. on Tuesday by the aid of fifteen tugs, and, after spending the night in Cowes Roads, docked at Southampton on Wednesday morning. It is expected that the mishap will delay the liner's next voyage to New York until to-morrow, Saturday.

Generation of Electricity in 1945

The publication of the Electricity Commissioners Statistical Returns was, for national reasons, suspended in 1939, on the outbreak of war. At the request of the Commissioners, however, the authorised undertakers maintained their statistical records as fully as circumstances permitted so as to preserve continuity in the main statistics relating to electricity supply and to allow publication to be resumed after the war. A document recently published by the Stationery Office ("Generation of Electricity in Great Britain: Year ended December 31, 1945") contains analyses and summaries of the returns of fuel consumption and units generated during 1945 at the stations operated by authorised electricity undertakers. While the Commissioners have not felt justified in including full details for each of the intervening years, the publication maintains a measure of continuity in two additional tables which give certain salient figures for each of the six years between 1938 and 1945. During 1945 the 346 stations operated by electricity undertakers generated 37,284,597,992 units, a decrease of 2·8 per cent on the corresponding figures for 1944. Of the units generated, the proportion used on works was of the order of 5·7 per cent. These stations consumed 22,821,088 tons of coal and coke, which was 2·7 per cent less than in 1944. The consumption of fuel oil, on the other hand, increased from 18,008 tons in 1944 to 19,741 tons in 1945. An appendix to the return under review shows that, during 1945, the generating stations of railway and transport authorities and certain non-statutory stations were responsible for an output of 1,384,383,374 units generated, with a consumption of 1,002,908 tons of coal and coke and 45 tons of fuel oil.

Historic Researches*

No. XXIV—MOLECULAR PHYSICS

(*Continued from page 304, April 11th*)

THE work of Joule, Clausius and Maxwell which we have been surveying enabled physicists to interpret satisfactorily a number of important gaseous phenomena in terms of the dynamical theory. There were, however, several equally important phenomena which the theory as yet could not explain, and some even which seemed to be irreconcilible with it.

A common form of criticism was the assertion that the high velocities assigned to the molecules were incompatible with the slow speed at which some gaseous phenomena took place. For example, the mean velocity of the molecules of ammonia gas at room temperature was, according to the dynamical theory, of the order of 600 m per second. Yet, said the critics, it was a familiar fact that the diffusion of ammonia gas throughout a room occupied a considerable number of seconds as judged by the sense of smell. Again, the conduction of heat through a gas was far from being almost instantaneous, as it should be if heat were really identifiable with the kinetic energy of the molecules, and if the molecules moved with the alleged high speeds.

Criticism of this kind had the effect of inducing physicists to take the next great step in the development of the dynamical theory. They replied to it by asserting that the molecules of a gas did not travel from one end of a room or containing vessel to the other in straight lines. They collided with one another and at each collision their direction of motion was changed and therefore they proceeded from one point to another along zig-zag paths. The high calculated velocities related to the speeds between collisions and not to the rate of net displacement in any linear direction.

To substantiate this argument physicists had to discover some means of calculating the average distance traversed by the molecules between successive collisions—or the "mean free path," as it was called—and then, selecting some gaseous phenomenon or characteristic dependent upon the mean free path, to show that the calculated values harmonised with experimental results.

The first attack on the problem of the mean free path was made by Clausius. His argument was simple, but it yielded results which subsequently were proved to require only minor correction.

Clausius approached the subject by supposing in the first instance that the molecules of a gas were stationary and uniformly distributed with their centres at some common distance, say, l, apart. In other words, he pictured the volume of the gas as subdivided into elemental cells each of volume l^3, and each containing one molecule. Into this imaginary structure he supposed a single moving molecule to be injected. Any one cell would present a face of area l^2 through which the moving molecule might enter it. Of that total area, however, a portion would be blocked by the stationary molecule inside the cell. If the molecule were regarded as a sphere of radius r the blocked area would amount to πr^2 and therefore the free area area would be $l^2-\pi r^2$. Clausius argued that the ratio of the blocked area to the whole area, or $\pi r^2/l^2$, represented the probability that the moving molecule would collide with the stationary molecule. Similarly, he argued that the ratio of the free area to the whole area, or $1-\pi r^2/l^2$, represented the probability that the moving molecule would pass through the cell without colliding with the stationary molecule.

Proceeding with this line of argument Clausius next supposed that not one, but a number of molecules, say, n, were injected into the mass of stationary molecules. For convenience, let us write p for the ratio $\pi r^2/l^2$. Then Clausius contended that of the n injected molecules the probable number which would suffer collision in the first layer of cells would be pn, while $(1-p)n$ of them would pass into the second layer of cells without collision. Of the number which reached the second layer, the same proportion, p, would suffer collision and the same proportion, $(1-p)$, would pass on into the third layer of cells. And so on, in the manner of the law of compound interest.

The pn molecules which suffered collision in the first layer of cells could be assumed to have travelled the width l of the cells before colliding with the stationary molecules. Thus the aggregate of their free paths would be pnl. In the case of the molecules which suffered collision in the second layer of cells, the free path of each up to the collision could similarly be taken to be $2l$, and therefore the aggregate of the free paths of these second-layer molecules could be written down. And so on for the molecules which suffered collision in each successive layer of cells. Adding up all the aggregates and dividing the result by n, the total number of molecules injected into the imaginary mass, Clausius arrived at the average value of the paths traversed by the moving molecules before colliding with the stationary molecules, that is to say, at the "mean free path." The result is very simple. As shown in detail in the accompanying mathematical note, the value of the mean free path on the basis of this argument comes out at l/p or $l^3/\pi r^2$.

Clausius completed his study by extending his argument to cover the fact that the molecules of the gas were not stationary. If it were assumed that all of them were moving with the same velocity he found that the mean free path would be only three-quarters of his first value, or $0{\cdot}75\,l^3/\pi r^2$. In 1860 Maxwell carried the subject a stage further by taking into account the fact that the molecular velocities were not uniform, but were distributed in accordance with his own law. After much labour, he found that Clausius' correcting factor of 0·75 should be reduced to $1/\sqrt{2}$ or 0·707.

The value of the mean free path is thus determined by two quantities, l and r, both of which are unknown at present and neither of which can be directly measured. The length l may not have any physical existence, but it is definite enough. A given volume of gas must contain a finite number of molecules and therefore dividing the volume by the number we get an elemental volume which we are justified in describing as the average volume of space within which we can expect to find a single molecule. The quantity l is the length of side of a cube of volume equal to the elemental volume.

The mind can thus readily picture the meaning of the length l and can at once deduce two characteristics of it. Avogadro's law states that equal volumes of different gases at the same temperature and pressure contain the same number of molecules. It therefore follows that the length l is the same for all gases at the same temperature and pressure. Secondly, if we do anything which alters the volume of a given mass of gas, we must thereby produce an alteration in the length l. Thus, if the gas is compressed l will be decreased; if it is heated at constant pressure l will be increased; and if it is heated at constant volume l will remain unaltered. The value of the mean free path will be similarly affected in so far as it is determined by the length l.

The other factor entering into the expression for the mean free path, the "radius" r of the molecule, is much less definite. If the molecules are regarded as spheres of radius ρ a moving molecule will escape collision with a stationary molecule only if its path carries its centre past the centre of the stationary molecule at a distance greater than 2ρ. The area effectively blocked by a molecule of radius ρ is thus $4\pi\rho^2$, and therefore the quantity r must be considered to be twice the real radius ρ. The molecules, however, cannot, in general, excusably be regarded as spheres. If the atoms are spheres then two or more atoms grouped into a molecule cannot form a sphere. Further, the nature of a collision between two molecules is indefinite. It might mean actual physical contact. If, however, the molecules exert repulsion on each other when their centres are within some distance of each other—and we are not entitled to ignore that possibility—then a "collision" in the sense of an event terminating any particular free path of a moving molecule may occur before actual physical contact is established.

To meet these various indefinite aspects of the problem, Clausius defined r as the "radius of action" of a molecule; that is to say, it is a quantity such that the area blocked by the molecule is πr^2, whether or no the molecule is spherical and whether or no it exerts repulsion on a closely neighbouring molecule.

To give practical effect to the theoretical calculation of the mean free path, a study had to be made of gaseous phenomena which could be shown to be dependent upon the value of the mean free path and which were amenable to experimental measurement. We have already mentioned two such phenomena, the diffusion of gases and their conductivity of heat. There is another one, their viscosity. These three phenomena, according to the dynamical theory, are simply three different aspects of the molecular motion, namely, the transfer by that motion of, respectively, mass, kinetic energy and momentum from a region of higher to a region of lower concentration.

The mechanism whereby one gas, say, hydrogen, diffuses into another, say, oxygen, can readily be comprehended in general terms. On release the hydrogen molecules are set free to penetrate the surrounding mass of oxygen molecules, but the rate at which they spread outwards in any given direction is retarded by the collisions which they suffer with the oxygen molecules, and also by those which they suffer among themselves. As a result of successive collisions the path followed by any one hydrogen molecule is a zig-zag in all three dimensions of space.

* Nos. I, II and III, on "Friction," appeared July 14, 21 and 28, 1944; Nos. IV, V and VI, on "The Mechanical Equivalent of Heat," appeared September 29, October 6 and 13, 1944; Nos. VII, VIII and IX, on "Electro-Dynamics," appeared March 9, 16 and 23, 1945; Nos. X, XI and XII, on "The Ether Drift Experiments," appeared August 3, 10 and 17, 1945; Nos. XIII and XIV, on "Specific, Latent and Atomic Heats," appeared December 7 and 14, 1945; Nos. XV, XVI, XVII and XVIII, on "Chemical Elements and Atoms," appeared August 2, 9, 16 and 23, 1946; Nos. XIX and XX, on "The Classification of the Elements," appeared September 27 and October 4, 1946.

Consequently, its net progress outwards in a given time is determined not only by its velocity but also by the number and magnitude of the changes in the direction of its path produced by the collisions which it suffers in the given time. While the hydrogen molecules are spreading outwards among the oxygen molecules some of the oxygen molecules are, in a similar manner, spreading into the space originally occupied by the hydrogen molecules. The result of both processes determines the rate of diffusion.

Since the velocities of the individual molecules and the direction and lengths of their paths between collisions are of an entirely random nature, the theory of probability can be applied to discover the chance that a hydrogen molecule will have penetrated among the oxygen molecules a given distance in a given time. The result of the analysis, if it could be carried out with certainty, would yield an expression for the mass of hydrogen crossing, in a given time, a given area at a given distance from the point of release; that is to say, an expression for the coefficient of diffusion. There are, however, several difficulties in the way of effecting the analysis. For example, it is evident that the mean free paths of the two gases must be factors in the problem, but it is not quite evident how the lengths of these paths are to be calculated because we are no longer dealing with a mass of molecules all of the same size, but with a mixture of molecules of two different sizes.

Thus simple as the general mechanism of gaseous diffusion may appear to be the formulation of an expression for the coefficient of diffusion in terms of fundamental molecular characteristics is beset with difficulties. In addition, it is far from easy to carry out experiments on the diffusion of gases in all the detail and with the accuracy required to check the soundness of any theoretical formula which may be set up. The result is that several formulæ for the coefficient of diffusion of a gas exist and that none of them has been completely confirmed by experiment.

The general mechanism of thermal conductivity in gases is very similar to that of diffusion. Imagine a cube of gas to one face of which heat is applied. The molecules adjacent to the heated face acquire increased kinetic energy, but it is exceedingly improbable that any of them will pass directly to one of the other faces of the cube and there deliver up its increased stock of energy unimpaired in amount. The heated molecules will penetrate the mass of unheated molecules and colliding with them will pass on to them some share of their increased kinetic energy. The molecules heated in this secondary manner pass on to other molecules some share of their increased energy, and so on. Since only part of the increased energy of one molecule is passed on to the next with which it collides, the molecules nearest the heated face will, in general, have a higher amount of increased energy than those more remote from that face. In other words, a temperature gradient will be established throughout the gas. This gradient will persist if the rate at which energy is supplied at the heated face balances the rate at which it escapes from the cube at the other faces.

As in the case of diffusion, the formulation of an expression for the thermal conductivity of gases in terms of fundamental molecular characteristics is beset with difficulties. One important source of doubt originates in the fact that Maxwell's law for the distribution of molecular velocities is applicable only to a mass of gas at uniform temperature. It is not applicable as it stands if the gas possesses a temperature gradient.

We now come to the historic question of gaseous viscosity. Newton regarded viscosity as the friction experienced by a layer of fluid when it moves relatively to another layer with which it is in contact. The same idea still finds expression in most dictionaries. For example, Webster defines viscosity as "the internal friction offered by a fluid to the relative motion of its particles." To relate it in this manner to friction is to shirk the issue. Friction between solids is a reality, but we do not know its cause with certainty. It may be due to the interlocking of the rugosities of the surfaces in contact or to the welding together of their high points under the applied load. Neither of these theories can be invoked if the surfaces in contact are fluid and therefore to regard viscosity as being friction of some kind or other is uninstructive.

According to the dynamical theory, the viscosity of a gas is to be identified with the transference, by the molecular motion, of momentum from one layer of the gas to another when the layers move with different velocities. Consider a cube of gas divided into two layers by an imaginary horizontal plane. The random molecular motion results in the passage of molecules from one layer into the other. If there is no relative bodily movement between the two layers the momentum of the molecules passing from the lower into the upper layer in a given time must be equal to the momentum of the molecules passing in the same time from the upper into the lower layer. This must be true, because if the two amounts of momentum were unequal, one layer would gain momentum at the expense of the other, and the rate of gain in the one case and the rate of loss in the other would represent two oppositely directed forces, the existence of which would be inconsistent with the absence of relative motion between the two layers.

Let us now suppose that the upper layer is moving bodily over the lower layer with a uniform relative velocity V. On entering the upper layer a molecule from the lower layer finds itself surrounded by molecules possessing increased momentum, namely, that due to the addition of the mass velocity V to the normal mean molecular velocity v. On collision with one or more of these molecules it deprives them of some of their extra momentum and on returning to the lower layer it carries with it and passes on to the molecules of that layer the increased stock of momentum which it has acquired during its journey into the upper layer. A corresponding process takes place in the opposite direction. A molecule of the upper layer when it crosses the dividing plane carries into the lower layer the amount of momentum appropriate to the sum of the mass velocity V and the molecular velocity v. It finds itself surrounded by molecules possessing momentum appropriate only to the molecular velocity v. It is therefore in a condition to transfer some of its higher stock of momentum to the molecules of the lower layer and, on returning to the upper layer, to pick up from the molecules of that layer an amount of momentum equivalent to that which it has left behind in the lower layer.

The two processes are not compensatory. They act in the same direction and unite to rob the upper layer of momentum and to transfer it to the lower layer. So far as the upper layer is concerned, the momentum of which it is deprived is that, or part of that, due to the mass velocity V. In the stationary lower layer the momentum transferred appears as an increase in the stock which it possesses by virtue of the molecular velocity v.

Two results are obvious. If the mass velocity V of the upper layer is to be maintained against the continued loss of momentum to the lower layer, a force in the direction of V must be applied to the upper layer. The magnitude of this force is a measure of the viscosity of the gas. Secondly, the increased molecular velocity v, which the lower layer acquires by virtue of the transference to it of momentum from the upper layer implies, on the dynamical theory, that the temperature of the lower layer must increase. Such a rise in temperature is commonly observed to accompany any phenomenon or action bringing the viscosity of a gas—or liquid—into play.

The argument presented above in explanation of the general mechanism of gaseous viscosity lends itself to mathematical discussion. If it is assumed for the sake of simplicity that all the molecules have the same molecular velocity v, then it can be shown in an elementary manner that the argument leads to the conclusion that the coefficient of viscosity of a gas should be expressed by the relationship $\eta = {}^1/_3 \rho v L$, where ρ is the density of the gas, v is the root mean square molecular velocity, and L is the mean free path. If it is assumed that the molecular velocities, instead of being all equal, are distributed in accordance with Maxwell's law, it is found that the numerical coefficient has to be changed from $^1/_3$ to 0·3226. Maxwell's law is, however, applicable only to a gas at rest or moving with a uniform mass velocity throughout its volume. It is not strictly applicable to a gas moving in layers, each possessing a different mass velocity. This consideration involves a further modification of the numerical coefficient and requires us to write the relationship as $\eta = 0{\cdot}2853 \rho v L$.

The theory of viscosity, as we have here outlined it, was established in 1860 by the separate labours of Clausius and Maxwell. At that date practically nothing had been done on the experimental study of gaseous viscosity. The subject at once assumed outstanding importance. If the coefficient of viscosity of a gas were determined experimentally, the length L of the mean free path would be directly calculable from the theoretical formula. Interesting as a knowledge of that length would be, it would, however, prove nothing as to the soundness of the viscosity formula or, indeed, as to the soundness of the dynamical theory of gases on which it was based.

There were, in fact, two features of the theoretical result which in the existing state of knowledge were received with incredulity, and which were regarded as constituting a supreme test of the validity of the dynamical theory. These features were the implied influence of temperature and pressure on the viscosity of a gas. If a given mass of gas were heated at constant volume, its density ρ would not alter and neither presumably would the length L of the mean free path. But the molecular velocity v would increase with the temperature. Hence, according to the formula, the viscosity of a gas should *rise* as the temperature was raised. It was pointed out that this deduction was completely opposed to the behaviour of oil, treacle and other viscous liquids, which invariably responded to a rise in temperature by flowing more readily.

As regarded pressure, it was pointed out that any increase of it would raise the density ρ of the gas, and that the increased number of molecules in unit volume would

result in a greater frequency of collision, and therefore in a shortening of the mean free path L. The two quantities would therefore be affected in opposite directions, and therefore their product would remain unchanged. As for the third quantity, the molecular velocity v, it would alter only with change of temperature and not with change of pressure by itself. Thus the theoretical formula implied that the viscosity of a gas should be the same at all pressures.

Maxwell and O. E. Meyer proceeded independently and almost simultaneously to examine these two vital points experimentally. The method which they, and subsequently numerous other experimenters, employed consisted in observing the rate of decrement of the oscillations of circular discs suspended in an atmosphere of the gas under investigation, the temperature and the pressure of the gas being varied. The experiments triumphantly vindicated the theory of gaseous viscosity and through it the broader issue, the validity of the dynamical theory of gases. The viscosity of gases is independent of the gas pressure, except at very high and very low pressures. The viscosity of gases increases with the temperature, although not in strict accordance with the rate predicted by the theory which would make the viscosity rise in proportion to the molecular velocity v; that is, in proportion to the square root of the temperature.

The experiments of Maxwell, Meyer and others not only confirmed the theoretical deductions; they were such as to enable the coefficient of viscosity η to be measured directly. Modern research places the coefficient of viscosity of hydrogen at 0 deg. Cent. at the value 0·000086. The density of hydrogen at 0 deg. Cent. and 760 mm pressure is 0·00008985 gm per cubic centimetre. At the same temperature and pressure the root mean square velocity of its molecules has already been found, by means of Bernoulli's formula, to be 184,000 cm per second. With these values of η, ρ and v we can at once calculate that the length of the mean free path of the molecules of hydrogen at standard temperature and pressure is 0·0000183 cm. The arithmetic mean velocity of the molecules, as previously found, is 169,500 cm per second. Dividing that figure by the mean free path, we get the number of free paths begun and ended by the average molecule in a second; that is to say, the number of collisions which it suffers in that time. The answer is of the order of 9000 million.

* * *

With that figure—astounding alike in its magnitude and in its amenability to calculation by man—we bring to a close this short account of the interplay of theory and experiment by which molecular physics was raised from a state of pure speculation on to a firm, assured basis. The story as we have told it is far from complete. We are fully aware that we have omitted much that might and should have been included. We have, for instance, not discussed the implications of the fact that no real gas rigorously obeys Boyle's law nor the manner in which the revision of that law by Van der Waals and others was employed to gather fresh data, such as the diameter or size of molecules and their distance of separation.

The most notable omission which we have been compelled to make is, however, that of all reference to the determination of the absolute mass of a molecule. That subject by itself would provide a theme for a whole volume, and still not be exhausted. In 1933 over eighty different methods of determining the masses of molecules were on record, and since then others have been advanced. The earliest effort in this direction dates back to 1877 and was based on a statistical study of the Brownian movements which pollen grains, particles of gamboge and other very light finely divided substances suspended in a liquid can be seen to execute when viewed under a microscope. A much more accurate method is based on the evaluation of the electric charge carried on a single electron. But with the introduction of the electron we leave the domain of molecular physics and pass into the still vaster one of atomic physics.

Mathematical Note

Mean Free Path.—Let $p=\pi r^2/l^2$. Then of the n molecules injected into the first layer of stationary molecules, pn will suffer collision in that layer and the aggregate of their free paths will be $pn \,.\, l$. Of the $(1-p)\,n$ molecules which pass on into the second layer, $p\,(1-p\,)n$ will collide in that layer and the aggregate of their free paths will be $p\,(1-p)\,n \,.\, 2l$. In general, the number of molecules which reach the xth layer without suffering collision will be $(1-p)^{x-1}n$ the number which collide in that layer will be $p\,(1-p)^{x-1}n$, and the aggregate of the free paths of these colliding molecules will be $p\,(1-p)^{x-1}\,n \,.\, xl$. The total of the aggregates will be

$$pnl+p\,(1-p)\,n \,.\, 2l+p\,(1-p)^2n \,.\, 3l+\ldots p\,(1-p)^{x-1}n \,.\, xl,$$

or, dividing by n, the mean free path will be $L=pl\left\{1+2\,(1-p)+3\,(1-p)^2+\ldots x\,(1-p)^{x-1}\right\}$ Since $(1-y)^{-2}=1+2y+3y^2+\ldots\infty$, the sum of the series, if x is taken to infinity, is $1/p^2$. Hence $L=l/p=l^2/\pi r^2$.

Recovery of the "Pluto" Pipe Line

THE work of recovering the "H.A.I.S." cable pipe lines, which were laid from this side of the English Channel to France in the operation "PLUTO," is now well under way at berth 102 in the new docks of the Southern Railway Company at Southampton. Six 50ft diameter heaps of cable pipe line, each containing thirty miles, are being formed where, before the war, stood finely designed dock-side sheds which were damaged and badly burned during the bombing. It is likely that to these six coils a further three will be added later. Special gantries, which are illustrated herewith, have been designed and built to unload the cable.

LIFTING "H.A.I.S." PIPE LINE

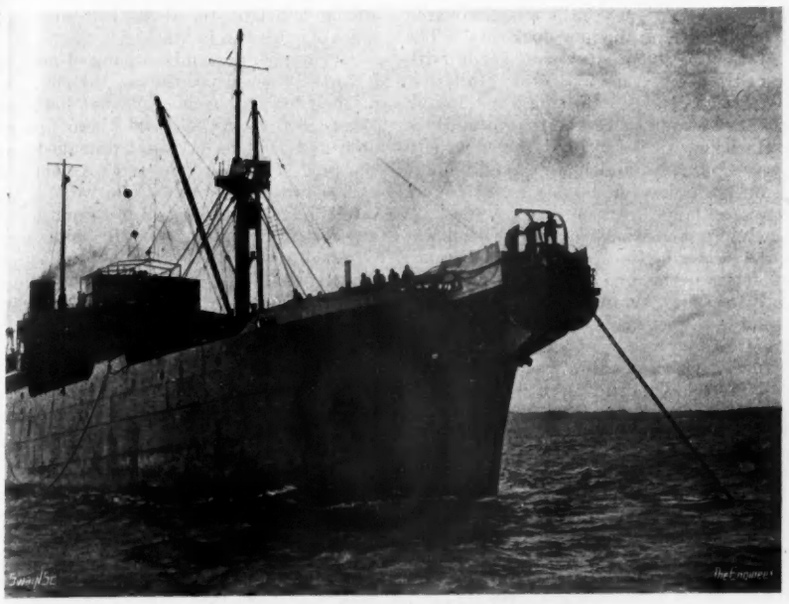
This interesting work is being undertaken by Marine Contractors, Ltd., of Royal Mail House, Southampton, on behalf of the Ministry of Supply. The ships engaged are the two cable laying ships, "Empire Ridley" and "Empire Taw," perhaps better known to our readers as H.M.S. "Latimer" and H.M.S. "Holdfast," which laid the pipe lines. They have been chartered by Marine Contractors, Ltd., for the work of recovery, which it is anticipated will be completed by the end of the year. By that time, recovery operations will, it is hoped, have afforded no less than 12,000 tons of high-grade lead. In addition, Marine Contractors, Ltd., is using its own tug and tender, which during the war saw service as a motor minesweeper, and which has now been converted to its present use.

The Reclamation Plan

Early in 1946, considering the existing shortage of lead and its present high price, the Ministry of Supply suggested to Captain J. O. Ingram, of Southampton, who during the war was one of the principal salvage advisers to the Ministry, that an organisation should be set up to undertake the salvaging of the thirteen "H.A.I.S." pipe lines. The firm of Marine Contractors, Ltd., agreed to alter its salvage programme and devote itself whole-heartedly to the undertaking, with Captain J. O. Ingram as managing director, assisted by his son, Mr. J. M. Ingram. The "Empire Taw" and "Empire Ridley" were duly chartered from the Ministry of Transport, but some time was needed to bring these two naval ships up to the standards of the B.O.T.'s regulations regarding the safety and navigational equipment of merchant vessels and the accommodation for the officers and men. By August, 1946, the first

ship, the "Empire Taw" was ready for the work, and by September the larger cable ship, "Empire Ridley," was also ready for service.

Interest attaches to the grouping of the pipe lines, which it was proposed to cover.



"EMPIRE RIDLEY" LIFTING "H.A.I.S." PIPE LINE

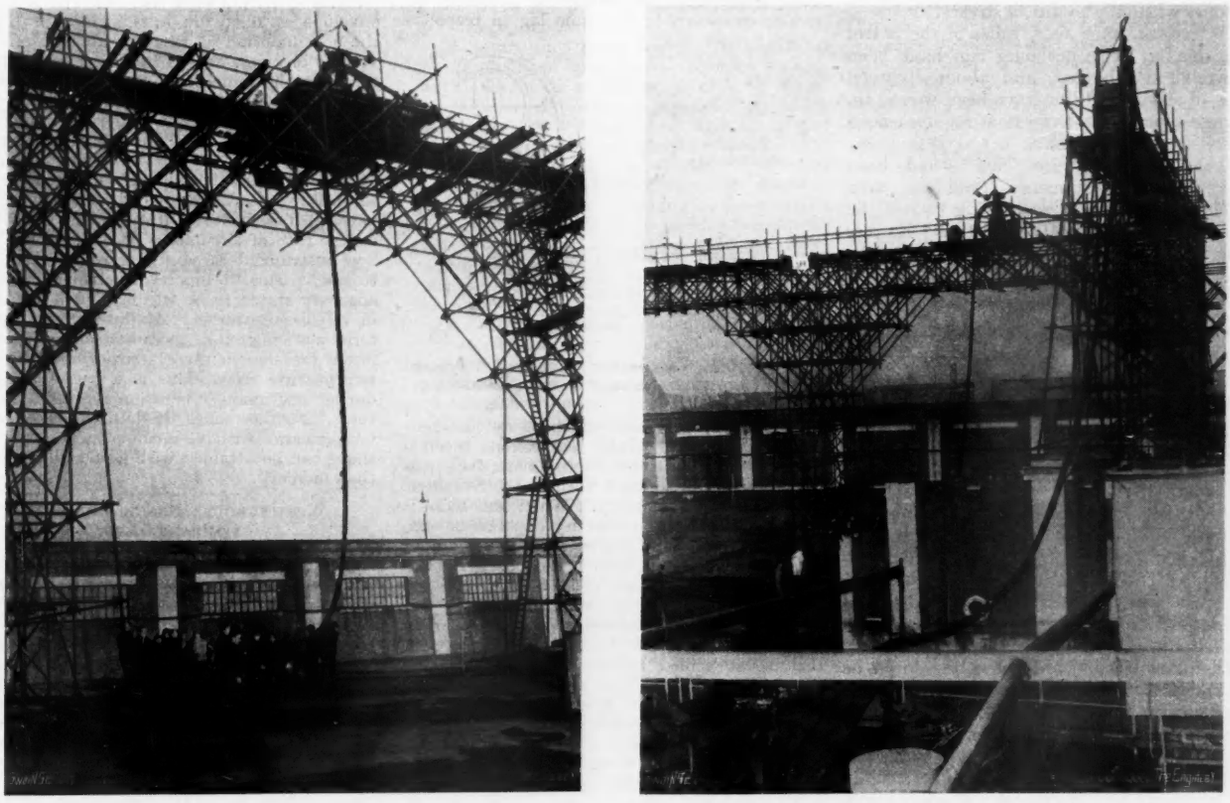
The pipe lines laid included thirteen lengths of "H.A.I.S." cable pipe line and eight lengths of "Hamel" steel pipe, the latter laid, it will be recalled, by unrolling from a 45ft diameter "Conun" drum. It is the "H.A.I.S." lines alone which are being dealt with at the present time. Such lines were laid between Ventnor, in the Isle of Wight, and Cherbourg, and between Dungeness and Boulogne.

Two "H.A.I.S." pipe lines were laid between Ventnor and Cherbourg, one for high octane petrol and the other for fuel oil. In addition, there were also two "Hamel" steel pipe lines. The distance is about sixty-five miles. The "H.A.I.S." pipe lines between Dungeness and Boulogne are eleven in number, together with six "Hamel" steel pipe lines, and the length of each of these pipe lines is about thirty miles.

Work of Recovery

The first work done by the cable ship "Empire Taw," with two cable tanks, was the picking up of the end of the No. 1 Ventnor–Cherbourg pipe line. For reasons of safety the Navy had removed the length of pipe between the shore and the three mile limit. The loose end had to be located and raised, and was done by grappling in accordance with Captain Ingram's own method. When the end had been successfully buoyed, the "Empire Taw" was transferred to Dungeness to deal with the first Dungeness–Boulogne pipe line, and "Empire Ridley," with her two large cable tanks, was started on the winding in of the first Cherbourg pipe line, that which had been used for petrol supply. Before beginning the work, the contractors were informed that all the pipe lines had been cleaned by pumping water through them. This process did not, however, entirely prevent pockets of petrol remaining in the pipe lines. In one case, about half a mile from the end of a pipe line, it was necessary to cut the line, and as this was being done with an oxy-acetylene blow pipe, the presence of high octane petrol revealed itself, and the severed pipe line burst into flames. Happily, the severed part of the pipe was well over the bows of the ship, and the fire was extinguished with fire-foam without damage. It is of interest to record that the severed pipe spouted petrol for more than an hour. This, we are informed, was probably due to a large pocket of petrol, and the difference in specific gravity between the water and oil and the pressure of the sea at a depth of thirty fathoms. Later it was discovered that the pipe line contained practically pure petrol, the pockets of water being few and far between.

On the Ventnor–Cherbourg line the work



DISCHARGING AND COILING RECOVERED PIPE

of recovering the first "H.A.I.S." pipe line by the "Empire Ridley" continued successfully, until over thirteen miles had been wound in. At this point, however, heavy weather was encountered, and the pipe line broke, owing to its shearing on a sharp edge of the bow during a side movement of the ship in a heavy sea. The "Empire Ridley" put back into port and the sharp edge was removed by adding a half-round section of iron to the plate.

The recovery of the second pipe on this route—the one used for fuel oil—was then begun, and it was picked up steadily for fifteen miles. Bad weather then necessitated the cutting and buoying of the line, and the "Empire Ridley" again returned to shelter. When fine weather reappeared, recovery of the petrol line was recommenced. It was found, however, either that this line had not been laid exactly to plan or that it had moved on the sea bottom, for in some places it was overlaid by the steel "Hamel" pipes. On many occasions it was necessary to grapple for, and raise, the overlaid steel pipes, and a pull of forty tons was needed to bring the pipe to the surface. An idea of the tension in the steel pipes may be judged from the fact that when laid across the bows of the vessel it stretched for 200 yards on either side before touching the sea. In this position it was cut and the two ends disappeared into the sea clear of the "H.A.I.S." pipe line which was wound into the cable tanks on the ship as before. Some sixteen miles out a 300ft long wreck was found on top of the pipe line, and great skill was needed to clear the cable without breaking it and whilst contending at the same time with fierce currents which flow almost continuously at this point. Near Cherbourg, a further small wreck was encountered which was brought to the surface on the pipe line. It however broke away from its securing wires and sank. The work of grappling "Hamel" pipes and drawing the pipe line from below wrecked ships was done at a depth of thirty fathoms without the aid of divers.

Up to date, some sixty miles of the petrol pipe line on the Cherbourg run have been recovered and landed, and about eighteen miles of the second line have been wound in. Salvage operations have now recommenced on the second pipe line.

Meanwhile, "Empire Taw" had been engaged in the Dungeness–Boulogne area and had succeeded in recovering two of the "H.A.I.S." lines as well as assisting "Empire Ridley" as and where necessary.

Sites for Discharging

It was intended at first to land all recovered pipes at King George V Dock, London, where facilities for discharging by overhead gantries were already available. Unfortunately, this proposal could not be followed up without contravening Port of London Authority fire regulations on account of the petrol and oil in the pipes, and further the berth was urgently needed for other important shipping. Finally, it was decided to discharge the first lengths of pipe from the "Empire Taw" at Swansea. That port was chosen as the district was regarded as a development area in which work was needed. The site was unsuitable, however, as only small quantities of cable pipe line could be dealt with, and furthermore considerable extra coal was needed to bunker the ships, at Southampton for the voyage to Swansea, again at Swansea for the return voyage, and on arrival at Southampton to take on again full bunkers for the Dungeness–Boulogne run.

For this reason a site at Southampton was regarded as the best, and was urgently sought. The first site obtained was suitable for berthing the cable ships, but the quay wall would not take the deadweight of the discharged pipes, as it was only designed for 5 cwt per square foot, whereas the weight of coiled pipe line amounts to something over 1 ton per square foot. After a further search, a good site with excellent quay walls was discovered at No. 102 berth on the new dock site. The site of the burnt-out dock-side sheds with their railway and road access was all that was desired. The site having been found, approval was given by the Southampton Dock and Harbour Authority and the Southern Railway Company, and in forty-eight hours work on preparing for discharge was begun. That was in mid-November last.

A new problem which presented itself was that of discharging the pipe cable at a distance of 125ft from the quay side. A plan was devised for a new arrangement of the gantry and power driven sheaves, and within four weeks the site was ready for work. The construction of the gantry was entrusted to Scaffolding (Great Britain), Ltd., under the supervision of Johnson and Phillips, Ltd., makers of the cable machinery on the ship.

As the accompanying engravings show, the cable leaves the ship at right angles, and is taken to the top of the overhead gantry, where it is delivered horizontally along the length of the gantry, a power sheave being placed at the point at which it is desired to discharge the cable.

At present, four coiled heaps have been made. Each of them is 50ft in diameter, and at a height of about 15ft some thirty miles of cable can be stacked.

As the pipe descends, a gang of men guide it to the desired position in the coil. Much of the pipe has been somewhat flattened in the recovery process, and there are many damaged portions. At each damaged portion the pipe is cut through and a coned closing nozzle terminating in a globe valve is driven into the end of the pipe. As a consequence, any petrol remaining in the pipe can be pumped out and stored in tank wagons. Already 65,000 gallons of high octane petrol have been recovered. The pipe is now to be cut into convenient 6ft lengths and despatched by rail to suitable works for the recovery of the lead. The cutting will be done by an electrically driven drop stamp press.

For the engravings herewith reproduced we are indebted to Southern Newspapers, Ltd., of Southampton.

The Physical Society's Exhibition

No. II—(*Continued from page 310, April 11th*)

CONTINUING our review of the Physical Society's Exhibition, which was held in London from April 9th to 12th, we describe below a further selection of scientific instruments and apparatus that was shown by some of the 118 exhibitors in the trade section.

Negretti and Zambra, Ltd.

A new "fast bulb" mercury in steel thermometer was exhibited by Negretti and Zambra, Ltd., 122, Regent Street, London, W. 1. This instrument was designed primarily to reduce considerably the time lag in response to temperature change which is an inherent characteristic of liquid expansion thermometers. Normally in thermometers of this kind the bulb is filled with a thermometric liquid, such as mercury. When the bulb is heated or cooled the mercury expands or contracts in volume to a greater or lesser extent than the enclosing bulb envelope. The differential change in volume is then utilised to indicate the change in temperature. In such thermometers two factors contribute to thermal time lag. First, the bulb envelope must be heated or cooled before heat can be transferred to or from the mercury. Secondly, the mass of mercury is considerable, and its full change of volume is delayed until the mercury attains a uniform temperature throughout its mass. The resulting time lag can be considerable, especially so in some industrial transmitting thermometers.

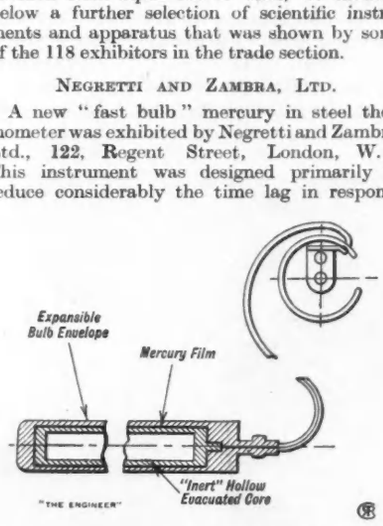


FIG. 6—"FAST" MERCURY-IN-STEEL THERMOMETER BULB—NEGRETTI AND ZAMBRA

As shown in Fig. 6, the new class of thermometer is so designed that the bulb envelope becomes the temperature sensitive member, while the effect of liquid expansion is virtually eliminated. Instead of the bulb being filled with thermometric liquid, the internal space is occupied by a close-fitting core or plug of "Invar," which is practically non-expansible and has low heat capacity and negligible thermal hysteresis. The bulb is made of stainless steel having a high and constant thermal coefficient of expansion. The very small annular space between the plug and the bulb envelope is filled by a thin film of liquid, the sole function of which is to transmit the volume changes, caused by changing temperatures, to the indicating head. This construction gives the bulb a very high ratio of surface area to sensitive mass which is an important factor in reducing the thermal lag coefficient.

It is claimed that the mean lag coefficient of the fast bulb thermometer is less than 0·5 seconds; tests have yielded values lying between 0·3 seconds and 0·4 seconds, depending on the rate of circulation past the bulb. The new instrument is sensitive, responding fully to sudden small temperature changes, with an accuracy stated to be within ± 0·3 deg. Fah. in all circumstances. An interesting characteristic arising out of the new design is that the liquid pressure in the system decreases as the temperature rises. This is a useful property during continuous operation at high temperatures. Further, since the bulb envelope is the temperature-sensitive member, a uniform scale shape can be attained with liquid fillings other than mercury.

Westinghouse Brake and Signal Company, Ltd.

One of the problems frequently encountered with magnetic voltage stabilisers of normal design is caused by frequency variations of the mains supply affecting the stability of the output voltage. To overcome this defect, Westinghouse Brake and Signal Company, Ltd., 82, York Way, Kings Cross, London, W.1, has developed a frequency-compensated a.c. voltage stabiliser, which was arranged for demonstration on its stand. The equipment, which is illustrated in Fig. 7, is known as the frequency-compensated Stabilistor, type B, and consists of an arrangement of transformers, chokes and condensers. The essential

features of the circuit are shown in Fig. 8; T1 is a double wound transformer with its windings interconnected with the auto-transformer T2. Across the output leads from these transformers is connected a filter circuit consisting of a condenser C and a choke L.

Output No. 2 is compensated for voltage and load, giving a performance which is exactly the same as the standard type A Stabilistor which was shown at last year's exhibition. The output voltage is 230 volts and any fixed or variable load from zero up to the rated load can be supplied.

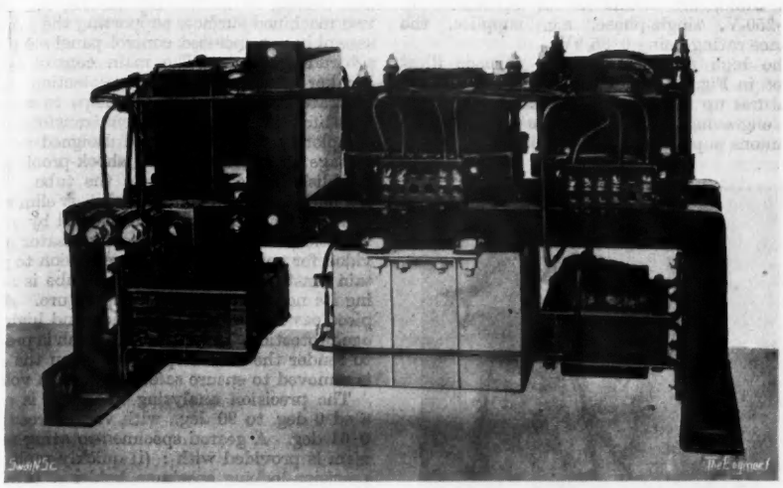


FIG. 7—FREQUENCY COMPENSATED STABILISTOR—WESTINGHOUSE

A second filter circuit comprises a condenser C2 and a choke L2.

As indicated in the circuit diagram, two separate output circuits are provided; the corresponding outputs are available alternatively but not simultaneously. Output No. 1 is compensated for frequency and voltage variations at the exact resistive load specified. Any desired output can be provided, and the required value must be specified when ordering the equipment. Owing to the high precision aimed at the circuit is designed for use only with constant resistive loads, such as photometer or printer lamps and valve heaters, &c., although it can be used to supply varying resistive loads, such as meter calibrating circuits, provided that arrangements are made to keep the total loading on the Stabilistor fixed at the correct value. Under these conditions the apparatus possesses an exceptional degree of stability; a change of 1 per cent in supply frequency causes an output voltage change of only 0·05 per cent, while a change of 1 per cent in supply voltage causes a variation in output voltage of only 0·04 per cent. These values will hold generally over a frequency range as wide as from 48 to 52

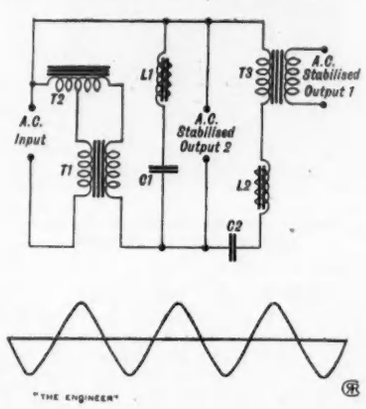


FIG. 8—THEORETICAL CIRCUIT DIAGRAM OF STABILISTOR—WESTINGHOUSE

cycles per second, and over an applied voltage range from 200 to 250 volts. Evidently, therefore, it is possible to obtain a very high value of short term stability, while a long term stability of a few parts in 1000 is obtainable on a reasonable mains supply. The out-

MARCONI INSTRUMENTS, LTD.

A measuring instrument of more than ordinary interest is the universal bridge, type T.F. 868, which was included in an extensive display of apparatus by Marconi Instruments, Ltd., St. Albans, Herts. The universal bridge is an a.c. mains operated instrument incorporating the necessary elements for three distinct bridge systems for inductance and capacitance measurements at 1000 c/s and for d.c. resistance measurements, the ranges being 1 μH to 100 H, 1 μμF to 100 μF, and 0·1 ohm to 10 megohms, respectively.

An interesting point about the design is the simplicity of operational controls; a single dial serves for the measurement of *L*, *C*, and *R*, in conjunction with a range-selector which makes the dial direct-reading without risk of confusion and without recourse to multiplying factors. The choice of bridge is effected by an *L-C-R* switch, which selects the required circuit and, at the same time, discloses the appropriate scale symbols (inductive, capacitive or resistive) at the viewing apertures in the balance dial, Fig. 9. Operation of the range control similarly discloses the required range figures.

The universal bridge incorporates a 1000 c/s oscillator and a tuned amplifier detector with a moving coil indicator for inductance and capacitance measurements. For resistance measurements the indicator is used directly as a centre zero galvanometer, the necessary direct current for the bridge being derived from the power pack supplying the oscillator and detector.

Inductance is measured by comparison with capacitance; the Maxwell or Hay circuit is used, depending on the Q of the inductor under test. Capacitance is determined by a resistance ratio arm bridge in which the final arrangement depends upon the losses of the component under test. When making inductance or capacitance measurements, selection of the final arrangement of the bridge circuit is made by the setting of a change-over phase balance control switch. This switch has two settings associated with two scales—one in terms of Q and the other in terms of tan δ; a conversion chart is fitted in the top of the instrument, inter-relating tan δ, Q, and power factor (sin δ or cos φ). For resistance measurements the phase balance control is, of course, inoperative and the circuit elements are simply connected as a Wheatstone bridge. The instrument accuracy is stated to be ± 1 per cent for inductance, capacitance and resistance measurements, except in the case of certain range extremes, when the accuracy is of the order of ± 5 per cent.

A tapped transformer makes the instrument suitable for alternative a.c. mains voltages of 220-240 V or 110–120 V. The mains on-off switch is surrounded by a removable escutcheon plate which indicates the voltage range for

FIG. 9—UNIVERSAL BRIDGE—MARCONI INSTRUMENTS

which the transformer is set. A similar plate on the transformer itself discloses the voltage tapping and at the same time makes the necessary connections. To change from one voltage range to the other all that is necessary is to interchange the escutcheons.

ELLIOTT BROTHERS (LONDON), LTD.

The apparatus exhibited by Elliott Brothers (London), Ltd., 72, Victoria Street, Westminster, S.W.1, included a wide range of instruments for industrial and laboratory use and a telephone dial selector for the remote indication of transmitted data. A photograph shown on the stand illustrated a piece of specialised equipment of unusual interest—a high precision voltage transformer designed to meet the requirements of the National Physical Laboratory, for use with the standard electrometer.

As illustrated in Fig. 10, the voltage transformer is an eleven range instrument, with primary voltages rated at 1, 2, 2·5, 3, 4, 5, 6, 7, 10, 11, and 12 kV, and a secondary voltage of 100 V. The N.P.L. specification required that for a secondary burden of 1 VA at unity power factor, the errors at a rated frequency of 50 c/s, from 30 to 110 per cent of nominal voltage, should be not greater than two parts in 10,000 for ratio and 0·5 minute for phase angle. The transformer was

FIG. 10—PRECISION LABORATORY VOLTAGE TRANSFORMER—ELLIOTT

to be used over the frequency range of 40 c/s to 100 c/s.

The core of the transformer is rectangular in section and is built up of 0·01in mumetal strips, supplied and processed with the co-operation of the Telegraph Construction and

Maintenance Company, Ltd., special attention being given to the flatness and tooling of the strips. The windings are built up on two limbs of the transformer core, the primary winding being in twelve sections connected to a series-parallel latchet board which gives the basic ranges of 1, 2, 3, 4, 6 and 12 kV. Equally distributed on the two limbs is the secondary winding which has tappings giving ranges of 600/7, 100, 1200/11, and 120 V. By using these secondary tappings in association with the appropriate basic primary ranges detailed above it is possible to obtain any of the desired intermediate primary ranges.

Special attention, in designing the instrument, has been devoted to the distribution of the windings so that the errors with series parallel connections for the various ranges shall be practically identical. The transformer is "dry," and the primary winding is wholly insulated for a test pressure of 24 kV. Each coil is taped with synthetic resin varnished paper to the required thickness and is then heat-treated under pressure in a special jig.

Measuring instruments shown on the same stand include a range of 3½in iron cored dynamometer instruments of new design, with an angular deflection of 220 deg. and suitable for use within the frequency range of 40 c/s to 400 c/s. Housed in hermetically sealed cases, these instruments are adapted to service conditions in any climate. The examples shown comprise a volt-meter 0·260 V, 40–400 c/s; an ammeter 0–100 amp., 40–400 c/s; a watt-meter for 3-phase balanced load, scaled 0–10 kW, 400 c/s, for use with current transformer ratio 30/1, and volt range 200/3; a frequency indicator for 300–500 c/s, 115 V.

Wild-Barfield Electric Furnaces, Ltd.

The two equipments illustrated herewith are typical of the range of electric furnaces exhibited by Wild-Barfield Electric Furnaces, Ltd., Watford, Herts.

The first of these equipments, shown in Fig. 11, is a laboratory muffle furnace, having chamber dimensions of 8in by 3in by 3in, which has been completely redesigned for laboratory work up to 1000 deg. Cent. A mild steel casing, reinforced by angle iron, contains the muffle, which is wound with nickel-chromium alloy wire. To improve temperature uniformity, allowing a greater length of the chamber to be employed usefully, the

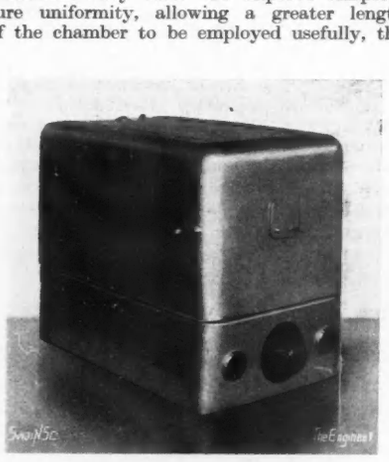


Fig. 11—Laboratory Muffle Furnace —Wild-Barfield

winding is specially graded so as to counteract the effects of the higher heat losses at the ends of the muffle. The chamber is held in position by centralising pads at the front and rear, the latter being backed by refractory brick. Powder insulation surrounds the muffle, reducing heat losses and running costs to a minimum.

All door gear is enclosed, but is readily accessible by removing the panels which form an outer shell at the sides of the equipment. The furnace casing is extended rearwards to form a compartment housing the terminal block and thermo-couple entry tube, together with a switch which isolates the heating elements when the door is open. A flue with a flap damper is provided. The base of the equipment houses an energy-regulator hand temperature controller, which maintains close temperature control over a wide range. Pilot lights are incorporated in the base to indicate "mains on" and "furnace on." Provision is made for the introduction of a suitable protective atmosphere. Standard models, entirely self-contained, with a 6ft length of three-core cable, are available for operation on 200–250-V, single-phase, a.c. supplies, the furnace rating being 0·85 kW.

The high temperature tube furnace illustrated in Fig. 12 is designed for work at temperatures up to 1700 deg. Cent. As shown in the engraving, the furnace is mounted on trunnions supported on a tubular steel frame-

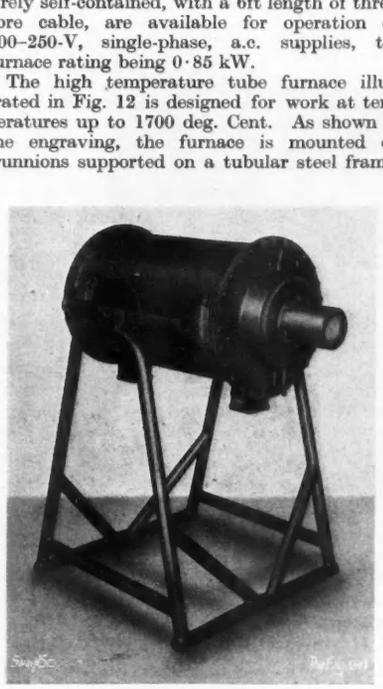


Fig. 12—High Temperature Tube Furnace —Wild-Barfield

work. Locknuts are provided so that the furnace tube can be held alternatively in the vertical or horizontal positions.

An external cylindrical casing of mild steel lined with high temperature insulation surrounds a refractory tube containing refractory granules. The molybdenum winding is embedded in an inner tube, which lies within the refractory tube. The furnace tube proper is of high temperature refractory material and a space is left between this tube and the tube containing the winding.

To prevent local overheating at the ends of the tube, water jackets with suitable outlet and inlet pipes are provided at each end. Oxidation of the winding is avoided by maintaining a suitable atmosphere within the furnace. The gas enters at one end, passes between the furnace tube and the winding, and is led away by a suitable outlet at the other end of the equipment, wedge type gas seals being fitted at each end. Leads out from the heating winding are taken to gas-tight terminals. The furnace is rated at 12 kW and the usable dimensions of the tube are 3in diameter by approximately 1ft 10½in length.

Philips Lamps, Ltd.

Quantitative and qualitative analysis of crystalline substances and certain amorphous substances can be made with the help of the Geiger counter X-ray spectrometer exhibited by Philips Lamps, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. In its latest form this equipment is now available with an automatic recorder.

The makers claim that under optimum conditions diffraction angle can be measured to within ± 0·03 deg. For certain applications, it is stated, the method has some advantage over conventional diffraction procedure, which entails exposure and development of film besides measurements and computations. The spectrometer provides a rapid method for directly determining location and intensity of diffracted rays. A scanning device, having a Geiger counter tube arranged to traverse a graduated quadrant, is used in combination with suitable measuring circuits. The intensity measurements are quantitatively accurate and can therefore be used to determine the composition of crystalline mixtures and components in quantities of 1 per cent or even less.

As illustrated in Fig. 13, the cabinet is of metal construction, with two hinged side panels, enclosing the h.t. transformer, control panel and cooling fan. The top casting consists of two machined surfaces supporting the scanning assembly; a recessed control panel eliminates protruding parts. The main control circuit-breaker provides overload protection and a separate h.p. control switch helps to conserve tube life. The h.t. and filament transformers are completely oil-insulated and designed for good voltage regulation. Two shock-proof cables establish h.t. connection to the tube. There is a built-in overall voltage stabiliser eliminating fluctuations in X-ray output caused by voltage variations. A special load compensator is provided for correcting filament emission to maintain constant current, while the tube is attaining its normal operating temperature. A one-piece casting provides radiation and high voltage protection. An interlock switch is provided to render the unit inoperative when the shield is removed to ensure safety from high voltage.

The precision analysing quadrant is graduated 0 deg. to 90 deg., with vernier reading to 0·01 deg. A geared specimen-rotating mechanism is provided with: (i) quickly replaceable precision-locking specimen holder; (ii) X-ray shutter and adjustable slit assembly (calibrated 0·001in to 0·050in), with adjustable beam-height slit; (iii) Geiger counter tube housing with positioning adjustments and adjustable slit system (calibrated 0·001in to 0·050in). The scaling unit incorporates a pulse amplifier, electronic scaling unit, pulse inverter, limiter, electronic timer and test multivibrator. It controls the pulses from the Geiger counter for operation of the frequency meter, and the electro-mechanical counter employed in recording radiation intensity.

All components are mounted on a single chassis, and a multivibrator facilitates calibration. The power supply for the electronic scaling unit and associated equipment is a self-contained assembly also on a single chassis,

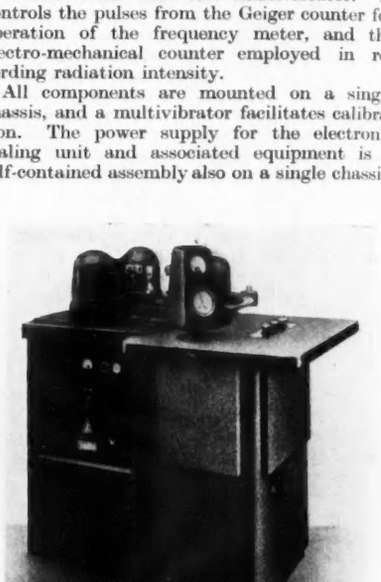


Fig. 13—Geiger Counter X-Ray Spectrometer—Philips

designed to provide plate, filament and grid potentials. A microammeter for indication of average frequency and a stepping counter to indicate scaled pulses are mounted in a substantial housing on top of the cabinet. The range of the Geiger counter power supply is 1050 V to 1600 V. It is electronically stabilised by a degenerative tube stabiliser with amplifier control. Stability is stated to be better than a few tenths of 1 per cent. The Geiger counter is specially filled for high efficiency; it has a low-absorption window. The threshold voltage is approximately 1250 V, and the response curve has a flat plateau. The resolving power is 2500 counts per second. A two-stage pre-amplifier unit is included in the housing.

Cooling of the X-ray tube is by radiation, assisted by a built-in fan. Tubes with copper or iron targets are available.

The automatic recorder provides for the use of a chart 12in wide and 120ft long, having a calibrated width of 11in, the chart speed being arranged for 30in per hour, with change gears for 60in, 90in and 120in per hour, the pen speed being full-scale travel in 4½ seconds. The complete recorder is enclosed in a dust and moisture-proof metal cabinet and is readily coupled to the Geiger counter unit. The Geiger counter X-ray spectrometer itself occupies a floor space of 2ft by 4ft, while the recorder occupies 2ft by 1ft 6in, and is available for operation on a mains supply of 220 V to 230 V at 50 cycles per second.

Marconi's Wireless Telegraph Company, Ltd.

Apparatus representing new developments in valve technique, a new lightweight radio compass for aircraft, and keying test equipment for quartz crystals were included in the exhibits shown by Marconi's Wireless Telegraph Company, Ltd., Chelmsford.

The airborne radio compass is an automatic D/F equipment which covers the medium frequency band of 150–2000 kc/s and provides a number of facilities. Briefly, the instrument gives automatic non-ambiguous bearing indication with simultaneous uninterrupted aerial reception of modulated or unmodulated signals. It provides aural D/F reception with aural sense determination, while optional manual visual indication is given with a left/right indicator and visual sense indication. The equipment is capable of omni-communication with a sensitivity of less than 1 microvolt for a 6 db signal-to-noise ratio. Radio-range reception is provided on all the above functions. As demonstrated, the receiver was completely self-contained in a single unit measuring 12½in by 8in by 5in, and weighing 15 lb. No separate power units are required, apart from the 28-V d.c. supply. Remote or local control of all functions can be provided. The total weight of a typical, remotely controlled installation, including tuning shaft and all interconnecting leads, is 35 lb.

The demonstration of keying test equipment for quartz crystals, mentioned above, was arranged to show how a production check can be applied to every crystal to ensure that the performance of the prototype is repeated. When a crystal drive is used in certain kinds of low-powered telegraph transmitters it is common practice to key the drive to ensure that no radiation can occur during the "space" periods. It is well-known that certain kinds of crystal cannot readily be keyed, except at very low speeds. The essential characteristic is that the crystal shall possess a low enough value of Q and this is satisfactorily achieved by the use of a "CT-cut" crystal, which can also offer the advantage of a low temperature coefficient. Such a crystal is, in addition, reasonably free from secondary modes, which is an essential feature when an untimed maintaining circuit is used.

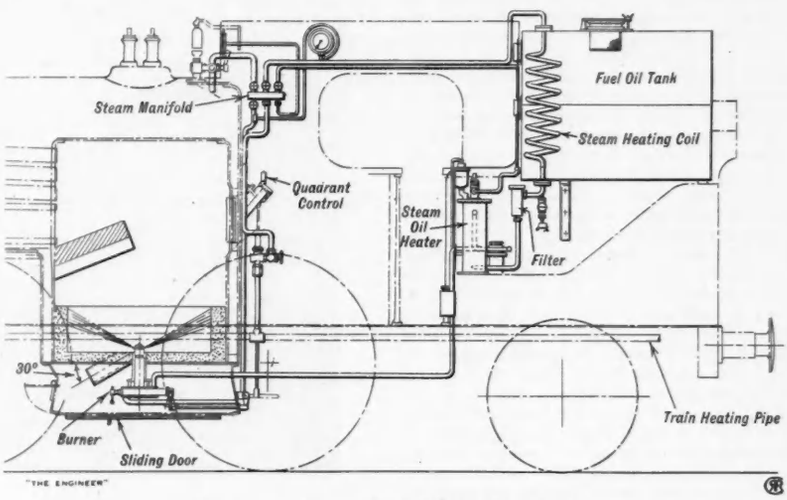
Having chosen a crystal possessing the required properties it is possible to obtain repeatability of performance in the further production of crystals by using the keying test equipment. This apparatus is designed to key the oscillator with a regular series of dots while the output from the oscillator is fed to the vertical axis of a cathode-ray oscillograph. The horizontal axis is fed with a substantially linear time base, triggered by the keying circuit, so that the envelope of the oscillator output during the period of "mark" is traced on the screen. A 200 c/s oscillator provides a timing signal. This signal is distorted to produce a series of sharp pulses which are applied to the grid of the oscillograph tube, giving a narrow black bar across the trace at every 5 milliseconds. Suitable precautions are taken to ensure synchronisation between the keying circuit and the timing oscillator so that the timing marks appear as a stationary pattern.

(To be continued)

Oil-Fired Locomotives on the G.N.R. (Ireland)

DURING 1936 and 1937 the Great Northern Railway (Ireland) carried out a successful experiment in the substitution of fuel oil for coal. The locomotive on which the trials were carried out was of the 4–4–0 two-cylinder type, and in the converted state worked main line express trains between Dublin and Belfast. As at that time adequate supplies of coal were available and the cost of fuel oil relatively high, the locomotive was subsequently re-converted to coal-firing. The experience gained, however, was sufficient to prove that the system adopted would be satisfactory should it ever be found necessary to carry out such conversions.

As the recent serious situation with regard to coal supplies made it imperative to reduce coal consumption to the absolute minimum, the company decided on a programme of conversions to oil-firing. Oil-burning equipment is now being fitted to tank engines of the "T 2" class, of which the company possesses twenty-five. The first locomotive was converted in September last year, and to date four of these locomotives are in service.



ARRANGEMENT OF OIL-FIRING EQUIPMENT

With the exception of a decrease in the length of the brick arch and the covering of the base and about 15in of the firebox side with firebrick, the conversion from coal to oil-firing is carried out without any structural alteration to the boiler firebox or smokebox. A vertical burner is used and the system adopted is that which has been developed by Laidlaw Drew and Co., Ltd

The system is designed with the following objects :—

(1) To improve upon the coal and oil comparative ratios which have so far been obtained in locomotive oil-firing. (2) (*a*) To eliminate local heating of firebox and tubeplate. (*b*) To reduce firebox brickwork to a minimum. (*c*) To avoid deposit of unburnt oil in boiler tubes. (3) To give controlled steam-raising, so as to reduce boiler stresses, by slow heating and even flame distribution. (4) To obtain a slow enough rate of combustion to enable steam pressure to be lost when standing, and to enable the burner to do this without use of a funnel blower and consequent loss of steam. (5) To give a range of flame control covering all normal train working requirements without having to vary the atomising steam pressure. (6) To eliminate all damper or secondary air control by the fireman by providing a smokebox and combustion chamber base design such that, covering the working range of the locomotive, any quantity of steam leaving the blast pipe is sufficient to produce a draught which will induce a quantity of combustion air sufficient to make steam only slightly in excess of engine demand. (7) An arrangement which will provide for a rapid change to solid fuel-firing and *vice versa*. The system allows the firedoor to be opened when the flame is lit and the normal tube blower can be worked without extinguishing the flame.

The arrangement of the oil-fuel firing equipment as fitted on the tank engines is shown in the diagram and it will be appreciated that the method of application is only rendered possible by the particular type of burner employed. The principle on which the burner nozzle is built allows it to be designed to produce a flame of predetermined shape, and for this particular application the nozzle employed produces a shaped flame having an included angle of 120 degrees.

The base of the combustion chamber is formed by a steel plate, ½in thick, and suitably stiffened, which is attached to the bottom of the firebox by the studs which also carry the ashpan. Combustion air is introduced through two rows of 4⅜in diameter tubes, arranged circumferentially, and welded into the base plate at an angle thereto of 30 degrees. The base of the combustion chamber is covered with firebrick which is extended up the sides of the firebox sufficiently far to prevent direct impingement of the flame on the water legs. The burner is disposed centrally in the base of the firebox pointing vertically upwards. The existing ashpan, having a front damper door only, has been retained. This door is used in the fully open position only when working, and is closed when the burner is shut off to avoid sudden cooling of the firebox and brickwork. A sliding door is provided in the bottom of the ashpan for the removal of the burner. A quick release device enables the burner proper to be detached and removed in one minute.

The steam supply for all purposes is taken from a manifold on the whistle stand when the engine is in steam, or through a connection when the engine is cold. This connection is coupled to the train steam pipe, to which an engine in steam can be connected for lighting-up purposes. In addition to the normal blower, which is used when engine is in steam, a blower connection to the same ring also takes steam from the train steam-heating pipe.

From the manifold outward connections are taken to the heating coil in the fuel tank, the oil line heater, the pressure gauge, and the burner. The supply of atomising steam to the burner is not superheated but is taken from the highest point of the steam dome to avoid water entering the pipes due to surge.

The steam pipe is provided with a control valve and burner steam pressure gauge.

The oil flows to the burner by gravity from a tank of 700 gallons capacity mounted in the coal bunker. This tank is fitted with a copper steam-heating coil. From the tank the oil passes through a primary filter, then through the oil line heater. This heater is fitted with a steam coil and thermostatic valve which controls the temperature of the heating steam exhaust, so as to maintain the correct oil temperature. On leaving the heater the oil passes to a twin strainer, and interposed in the pipe line between the strainer and the burner is a thermometer which indicates the temperature of oil reaching the burner.

When using steam from an external source with the burner lighted, ignition is instantaneous and steam can be raised in the minimum time consistent with avoiding undue stresses in the boiler.

Oil fuel consumption is stated to be approximately 4½ gallons per mile, whilst with the present poor quality coal, the consumption for tank engines working similar services is from 65 lb to 75 lb per mile.

The Fairey Guided Missile

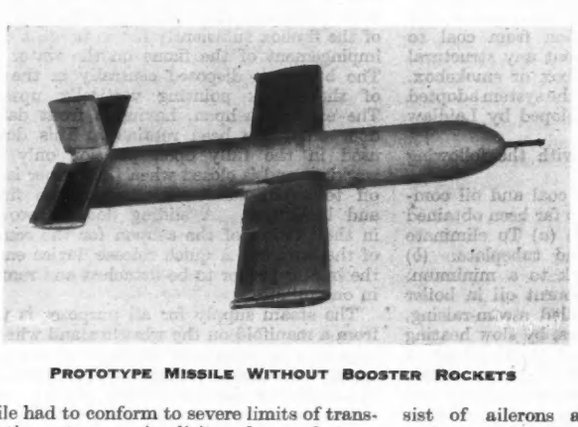
THE first British pilotless, radio-controlled rocket missile, illustrated herewith, which has been under secret development for eighteen months, has now successfully completed flight trials. This new missile was designed and developed by the research division of The Fairey Aviation Company, Ltd., and sponsored by the Directorate of Guided Projectiles, Ministry of Supply. It has been developed to the stage where a controller on the ground can exercise full flight control and pass the pilotless missile through a predetermined programme of aerial manœuvre.

Using four 75 lb thrust rockets, the maximum speed is stated to be in excess of 500 m.p.h. Smaller rockets, of 40 lb each, give a top speed of 350 m.p.h. We understand that the missile, on trials, using standard 3in booster rockets for take-off, attained a speed of 267 m.p.h. only two seconds after firing.

The development began during the closing stages of the war in the Pacific, when the Ministry of Supply specified a new type of weapon as a counter-measure to suicide-bomber tactics by Japanese pilots. Whilst only the preliminary discussions were in progress, Japan capitulated. Thus, the urgent need for production in quantity passed and the Ministry requested that work on the Fairey projectile should continue on a research basis.

The research division of the company tackled the problems vigorously and within seven months of the finalisation of the specification, the missile had been designed, manufactured and had undergone its initial aerodynamic test flight. The missile was envisaged as incorporating a warhead which would explode on its target and unavoidably blow itself to pieces. In the design offices it rapidly acquired the expressive code-name of "Stooge."

Particular mention must be made of essential requirements in the specification: the missile had to conform to severe limits of transportation, storage, simplicity of manufacture, and rapidity of assembly for action. "Stooge," in prototype was so designed as a series of components that, by the use of spigots and quick-release pins, a team of four men could assemble the missile—which has an all-up war weight of 738 lb—in less than 1½ minutes.



PROTOTYPE MISSILE WITHOUT BOOSTER ROCKETS

Structure of Missile

Of orthodox monoplane design, it has a cylindrical fuselage, 7ft 5½in long and 12½in in diameter, made up of a front and rear monocoque. The nose is streamlined in accordance with orthodox ballistic principles, but the tail end of the fuselage is untapered and open-ended, to allow egress for the gases from the venturis of the main rocket motor assembly.

The mainplane, comprising port and starboard wings, is set in mid-wing position at a positive angle of incidence of 3 deg., with a total span of 6ft 10in and chord of 17in. There is no dihedral or sweep-back on the mainplane. The wing tips are "clipped" at the extremities and for the special trial flights carried small observation flares.

The tailplane, which is similar in plan to the mainplane, has a span of 4ft and chord of 10in.

With the exception of the rear monocoque, which is of mild steel, the airframe members are constructed of duralumin. A rectangular tail fin encases the radio aerial, and is made of plastic material.

Control surfaces consist of ailerons and elevators only; experiments in the Fairey wind tunnel at Hayes showed that flying control could be effected entirely satisfactorily without the use of a rudder.

Rocket Motor Assembly

Propulsive power in the prototype is derived from a main motor assembly comprising four standard 5in "Swallow" rockets. The total thrust and burning time of these rockets is dependent upon the amount of charge packed into each rocket and, also, upon the size of the venturi orifices. During later flight trials the rockets and venturis used were adapted to produce 40 lb thrust per rocket during a burning time of 40 seconds.

To assist take-off, four booster rockets of standard 3in A.A. pattern are fitted externally in pairs on each side of the fuselage. The combined thrust of these boosters is 5600 lb, which is developed during a total burning time of 1·6 seconds. At the end of this time, the booster rockets are jettisoned by small black-powder charges which release each pair of rockets simultaneously from the forward attachments in the trailing edge of the mainplane.

Suitable interconnectors had to be devised to obviate the possibility of a rocket failing to fire, which would probably result in an uncontrollable yawing and rolling during take-off. The final design took the form of heavy castings which also ensured that each pair of rockets should drop clear, nose first, at the instant of jettisoning. Yet a third purpose is served by these castings, since the base of each casting acts as a shoe which rides over the rails of the projector ramp and counteracts any tendency of the projectile to roll during take-off. The weight and position of the booster rockets, which project about 2ft beyond the rear end of the fuselage, necessitate the installation of a counterbalance to keep the centre of gravity within permissible limits. Provision is therefore made for a nose ballast weight, which is jettisoned at the same moment as the boosters.

GUIDED MISSILE IN FLIGHT

Radio Control

The basic aim of the early designs has been simplicity, both in control and production. Control is exercised by the operator from a static site by moving a "joystick," mounted on a control box. An adjacent transmitter, linked to the control box, relays the initial impulses as radio signals on predetermined frequencies.

These radio signals are translated by utilisation of a "time-modulated" system into movements of the control surfaces through the medium of servo motors. In this system, control in the pitching and rolling planes depends on the relative durations of individual tones in pairs of audio frequencies. When the control stick is central the tones in each pair will be of equal duration and the servo motors and control surfaces will remain at rest. If the stick be moved, and the equal period timing be disturbed, a sensitive polarised relay operates the forward (and backward) contacts of the servo motors, and thus causes the control surfaces to respond.

The aileron control incorporates, in addition, a gyro unit, consisting of a "free" and "rate" gyro. This equipment ensures an angle of

bank consistent with the position of the joy-stick and also maintains lateral stability up to 80 deg. of bank. No rudder is fitted; turns are effected by a combination of aileron and elevator control. The structure of the projectile is stressed to withstand 7*g*. turns and is designed to be extremely manœuvrable by reason of sensitive response to movements of the control surfaces.

All equipment required for controlled flight is stowed internally. Radio instruments, servo motors, and batteries are installed in the forward compartment of the fuselage rear monocoque, leaving the aft section entirely free for the motor rocket assembly. The gyro is housed in the forward end of the front monocoque.

An external plug is situated on the starboard side of the front monocoque forward of the mainplane leading edge. By connecting an external battery to this plug the radio set can be warmed up. This permits the gyro to be speeded up before take-off, and thus conserves the output of the small internal batteries. The initiation of booster rockets, motor rockets and wing-tip flares is also incorporated in the external circuit. As the projectile moves forward on take-off, the external plug is pulled clear of its socket. By this action, the internal batteries circuit is automatically switched on.

Take-Off and Flight

For take-off, the missile is mounted on the rails of a 10ft ramp of light tubular construction. This ramp can be adjusted in elevation from 0 deg. to 45 deg. by a winding screw. A part of the ramp may be seen in one of the photographs herewith.

On firing the projectile leaves the ramp under an acceleration force of approximately 8*g*. for which the boosters are in the main responsible. No control is exercised by the operator until the boosters have been jettisoned, approximately 1·7 seconds after firing. When this period has elapsed, remote control of the elevators becomes possible. Not until a total of three seconds has elapsed is aileron control made available to the operator. This period allows for the stabilising of the projectile by the gyro after the jettisoning of the boosters.

American Engineering News

Aluminium Plate Girder Span

A new plate girder bridge on the New York Central Railroad consists of seven spans, of which four are 100ft long, and of which one is built entirely of aluminium, even to the rivets, thus affording an exceptional opportunity for observing the comparative performance of the steel and aluminium spans as to wear and corrosion. As completed in the shops, ready for erection, the weight of this span was 27 tons, while the steel spans averaged 64 fons. The particular alloy used has an ultimate tensile strength of 70,000 lb per square inch, with a tensile yield strength of 60,000,000 lb, an elongation of 13 per cent in 2in and a Brinell hardness of 135. Its weight is about 174 lb per cubic foot. By a special process a thin layer of another alloy is rolled on to both surfaces of the plates, as a protection. The ⅞in aluminium rivets, having an ultimate shearing strength of 33,000 lb, were driven by squeeze type riveting machines. But where rivets were inaccessible to these rivets they were driven by pneumatic hammers, one at heat-treating temperatures, giving an ultimate shearing strength of 24,000 lb. The web plates are 10ft deep, in 26ft lengths, requiring three vertical splices. The thickness is ⅜in, with 5in by 3½in angles for the vertical stiffeners, which are spaced 6ft apart. The flanges are 8in by 6in angles, with 14in cover plates, and a longitudinal stiffener angle, 5in by 3½in, below the flange angle. The aluminium span was built complete at the shops and delivered on railway platform cars, to be set in place by a crane. But the steel spans had to be shipped in sections and assembled at the site. The span was built with a camber of 1½in. All contact surfaces were coated or primed with a composition that remains plastic for a long period and will exclude moisture. For painting, the completed span was given a priming coat of zinc-chromate paint, followed by two coats of aluminium paint. However, owing to the aluminium's resistance to corrosion certain panels of the webs were left unpainted and will be subject to periodical observation.

Housing and Heating

In the problem of providing housing for the thousands of persons in the United States who are needing such accommodation, an important factor is the method of heating. In a small or large group of buildings the provision of individual heaters, with individual apparatus, individual fuel supply and individual control, will obviously be less economical than heating by a single or central plant with expert management. A recent report lists five types of central heating: vacuum steam, single-pipe steam, forced hot water, split system of steam to several stations equipped with converters, and the combination heating and cooling system. In small projects a 15-lb boiler pressure may be sufficient, but in the larger products the pressure may be up to 300 lb for a distribution pressure of 200 lb to 250 lb. The higher pressures are economical in general, as they require underground steam distribution pipes only about half the size of those required for the low-pressure system. With the split system the steam mains serve stations equipped with converters, from which high-temperature water is circulated to the individual houses. Cooling is as practicable as heating from a central plant. A second coil is built within the sheet metal casing of the main coil for steam or hot water. A solution for chilling the air in summer is circulated through this second coil. Domestic hot water can be generated at the central heating plant if the project is large enough to permit a drop of not more than 15 deg. temperature from the time the water leaves the hot water generator until it returns to the generator. The group system, employing two or more plants supplying heat and hot water for one project, is rarely economical, as these plants in the aggregate cost more initially and in maintenance and operation than the one central plant. Heating plants operated by tenants of the several buildings are rarely satisfactory as regards fuel consumption, smoke (coal or oil) and efficiency. Control systems effect a saving in fuel and in maintenance and operating costs.

Concrete Trestle Pier

A new pier nearly a mile in length, giving access to a loading berth for oil tankers in the harbour at Richmond, California, is of the trestle type, composed of concrete piles, beams and deck slabs. Two special features are the use of precast members, and the addition of emulsified asphalt to the concrete in preference to an exterior coating of asphalt to protect the members from corrosion by the salt water. The only concrete poured in place was that of the transverse beams seated on the heads of the piles, and here a third feature of interest is that instead of the usual wooden forms or shuttering, concrete shells were used placed upon the piles and becoming a permanent casing of the beams. These shells or forms were supported by temporary steel beams. Each cap or transverse concrete beam is carried by four concrete piles, 80ft to 90ft long, and the rows of piles are 20ft between centres. The deck slabs are 20ft long and 26ft wide for a 24ft or two-lane road, with concrete curbs surmounted by timber guard railings. To hold the slabs in place, they have cored holes for steel anchor bolts or dowels projecting from the concrete caps. Similar dowels in the pile heads unite the caps to the piles. After the pier was completed the deck was covered with a wearing surface of asphaltic composition 3in thick. The piles are 18in square in section, and were handled in the casting yard by a travelling gantry crane, having six points of attachment to ensure safe handling. A somewhat similar gantry handled the deck slabs. The cap forms were 28in wide and 30in deep, 3in thick for the bottom and 2in for the sides. Concrete for filling the cap forms was made on a barge which carried a mixing plant, material bins and a crane for handling and setting the cages of reinforcing steel in the cap forms. Placing the deck slabs progressed at the rate of eight per hour, and was done by barges equipped with cranes. These slabs were 7in thick, with a 24in beam under each side, and a 20in transverse beam under each end. They weighed about 15 tons for each slab.

Control of Flood Reservoirs

For the control of flood waters and the protection of life and property from floods, great reservoirs are being provided in practically all parts of the United States, since floods appear to increase in intensity, due partly to the fact that vast areas formerly available for natural flooding are now settled and developed. But when floods come the reservoirs need to be nearly empty in order to hold or detain the excess water. A difficulty arises in that many of these reservoirs are of the "multiple purpose" class, furnishing water for irrigation and hydro-electric power development. On a large drainage area or watershed there may be a number of such reservoirs, and to combine effective control with economic service it is necessary to regulate or operate them as units in a comprehensive system. On the Tennessee Valley system there are twenty-six dams on the Tennessee River and its tributaries, all of them of the multiple-purpose class. In this area, of some 40,000 square miles, floods are severe in winter and spring, moderate in late spring and summer, and light in the autumn. During the first season, the water in the reservoirs is drawn down to the lower level by about January, and by May or June the maximum amount of water is in storage. During the summer and autumn the stored water is gradually withdrawn, until the minimum elevation is reached, thus completing the cycle of operations. After the end of the heavy flood season, some storage space is retained in order to provide for sudden or "flash" floods. Lowering the level of the water is effected mainly by discharge through the turbines, supplemented by the opening of gates on the spillways, in the event of a wet or rainy season. During floods, however, the amount passed by the turbines is insignificant in comparison with that by the spillway, since the reservoir must not be allowed to fill to its maximum level.

The Chemical Society's Centenary.—The programme of the Chemical Society's centenary celebrations has now been published. The celebrations will begin on Tuesday morning, July 15th, with a reception of delegates and distinguished visitors, at the Central Hall, Westminster, S.W.1. In the afternoon the President, Professor C. N. Hinshelwood, F.R.S., will deliver a centenary address at the Central Hall, and in the evening there will be a dinner at the Dorchester Hotel, and a buffet supper and dance at Grosvenor House. On the morning of Wednesday, July 16th, two lectures will be given on "The Work of the Royal Institution in Physical Chemistry in Great Britain," by Professor E. K. Rideal; and "Chemical Personalities a Century Ago," by Professor J. Read. The first of these will be delivered at the Royal Institution, 21, Albemarle Street, W.1, and the second at the Institution of Civil Engineers, Great George Street, S.W.1. Visits to places of scientific interest in the London area are also being arranged for Wednesday, and in the afternoon Sir Robert Robinson, F.R.S., will deliver the Society's Faraday Lecture at the Westminster Central Hall. The University of London will entertain the delegates at dinner on Wednesday evening, and Imperial Chemical Industries, Ltd., is holding a reception at the Connaught Rooms, Great Queen Street, W.C.2. On Thursday morning, July 17th, further visits will be made to places of scientific interest, and in the afternoon there is to be a garden party at Hampton Court Palace. In the evening the Royal Institution is to give a sherry party to overseas visitors, and the Royal Society will hold a reception at Burlington House, Piccadilly, W.1. A centenary exhibition at the Science Museum, South Kensington, S.W.7, will remain open from July 14th until the end of September.

THE ENGINEER

APRIL 18, 1947

VOL. CLXXXIII No. 4760

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

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FRUSTRATION

A ONCE little-used word has in recent months found its way into everyday use. On the rare occasions when we got as far as the second verse of "God Save the King," we implored the Almighty to frustrate the knavish tricks of his enemies. At other times, the word was as little used in speech as in writing. In that constant friend and ally of the cross-worder, the "Oxford Dictionary of Quotations," it appears only as that quotation from the national anthem. But in a Concordance to Shakespeare it is found several times! Philologists will no doubt amuse themselves by seeking for the cause of the resurgence of the word. Maybe they will find it in the oratory of industrial reformers, for, if our memory serves us, it was used during the war to indicate the reaction of workers who toiled at tasks for they knew not what purpose, or who, after being urged to greater exertions, saw the fruits of their labour lying about the shops for weeks on end.

It often happens with words that they come into being or are lifted into new life by a specific need of the day. "Frustration" is such a word. It stands for a feeling of wasted effort or of foiled desires, an emotion from which few indeed now escape. The works manager who is doing his best to increase his export trade is frustrated by lack of materials, the shopper is frustrated by empty counters, the gourmand by empty dishes, the gourmet by empty sauce boats. Do we want a special book, our efforts to obtain it are frustrated by the publisher's announcement that it is "O.P." Do we want electricity, the dead switch frustrates us. Does the trade unionist want more pay for less work, he feels frustrated by the delays in negotiation. So it runs through the greatest things and the least; an inevitable consequence of a war of mutual destruction. The condition of mind induced is dangerous. On the one hand, it may lead to revolt and rebellion, as we see in unauthorised strikes; on the other, to lassitude and indifference. When people have been frustrated repeatedly they give up trying; they give up hope. It is not worth making an effort, it is not worth earning more money if one's desire to spend it is balked by lack of commodities. There is not even a stimulating sense of excitement in trying—an element perhaps in the pleasures of black-marketing—but absolutely nothing. A dismal blank; a complete frustration; a balking, baffling, neutralising, counteracting, disappointing outcome of one's labours.

It is because the word epitomises the conditions the world over at the present time that it is so well found. It is a warning finger writing on the wall a dreadful sequel to global war. And the only arms that we can take up against it are to reconcile ourselves to the inevitable. The old bit of waggishness anent expecting nothing and so avoiding disappointment is deadly truth. Let it be frankly acknowledged, and avowed by those who speak from high places, that the condition of the world is not such as to admit a higher standard of living, and the sense of frustration will be countered. Hard work and hard living must be the rule for some years to come, and the more openly that truth is proclaimed, the more frequently it is impressed on all classes of society, the less likely is the sense of frustration to weaken our wills and our determination to make the best of a bad business with a lively hope that better times lie ahead.

INCENTIVES AND OUTPUT

THE Economic Survey for 1947 gives the target for the distribution of the national income for this year and shows that, even if the target is reached, the proportion of the national income to be spent on personal consumption will be less than in 1938. If that distribution is accepted, it follows that the standard of living in this country can be increased only by a greater total output. In the long run that output can undoubtedly be achieved by the more efficient use of machines and by the more efficient use of manpower. But the increased output which can eventually be obtained by more modern methods of production and by greater mechanisation cannot be expected to be realised for some time and the only hope of a return to our pre-war standard of living in the near future lies in the more efficient use of manpower. The need for greater output per man year is stressed in the Survey. Yet at the same time constant demands are being made by workers for shorter hours and for a larger share of the national income, that is for more goods and services. The Survey emphasises that shorter hours can only be justified if they increase production and that great importance is attached to incentives to encourage more effort.

Considerable controversy has always raged around the questions of payment and hours of work. Arguments about the optimum length of the working week are often confused by historical, political and sociological factors which make any detached judgment very difficult. But, at least it does seem probable that if conditions were such that every man gave of his best during the whole of the time he was at work, a considerably greater production could be obtained from even shorter hours than those current to-day. It is commonly assumed that workers must have better baits dangled in front of them before they will work harder; and that they have no natural inclination towards work, either for its own sake or as a contribution to the general good of the community. This view seems to do less than justice to the people of this country, who have shown time after time in their history their ability to rise to great efforts in the face of difficulties. Without attempting to deny the value of financial incentives, it does, therefore, seem worth while to consider whether such incentives are always likely to be effective. Financial incentives have, in the past, often seemed to lead to very considerably increased production. But how much of that increase has, in fact, really been a consequence of improved methods of production introduced as a result of the attention attracted to the process by the increased earnings of workers or by the desire of the management to increase output? Moreover, it should not be forgotten that the introduction of financial incentives has undoubtedly lead to a great deal of suspicion between workers and managements about the justice of the standards on which incentives are paid, and to a considerable increase in the non-productive staff required for the setting of rates and the checking of output. Further, the introduction of competition between workers by the setting of individual piece rates has often given rise to an undesirable reaction by the workers, under which the earnings of those capable of very high output have been limited by a voluntarily accepted discipline of the working group, ensuring that no one outshines his fellows by too great a margin. It is, too, very probable that financial incentives become less and less effective as basic wage rates rise. It is a fact also that surveys among workers asking them to place conditions of employment in order of importance have always shown earnings to be low on the list; security, justice, job satisfaction, and other factors are always put above earnings.

The conclusion must be that though financial incentives are not without great value under suitable circumstances, they do not necessarily provide sufficient goals for the workers of this country. If bigger and better baits are the only means advanced for increasing output, then increase of output may come to be judged not by its value to the community, but by the better bait it can command. If we believe that there is any spontaneous urge to work for the common good in the people of this country, then we must surely examine what it is which will allow that urge to express itself and what it is that frustrates it

Earnings and shorter hours are very important, but the drive for greater output per man-year will, we think, inevitably give disappointing results if other factors are not taken into consideration. Is not the problem partly, if not even primarily, one of maintaining and raising the morale of the working group, rather than that of rewarding individual effort alone? Security, identification with each other in the common task, and a feeling of taking part in the solution of the problems confronting them—in short, team spirit—are all factors which help good morale. That team spirit was particularly noticeable in the way in which under the recent coal crisis managements and men worked together to keep production going. How best can that spirit be maintained over ordinary everyday working hours?

The Institution of Naval Architects

No. IV—(*Continued from page 306, April 11th*)

THE first paper read on Thursday afternoon, March 27th, was "Corvettes and Frigates," by A. W. Watson.

A lengthy discussion took place, from which we abstract the following.

Discussion

Mr. J. M. Murray said that from the structural point of view, the most interesting class was the prefabricated "Loch" class. The longitudinal scheme of framing proposed by Mr. Adam was extremely suitable for prefabrication, and the structural soundness was evident. In the actual construction of this class there were many difficulties to be overcome and a tremendous amount of detailed planning to be worked out. The success of the venture was due, in a large measure, to the careful way in which the production was organised, down to the very smallest details, by the various departments concerned. For the structure itself, the various parts came together very well, and the outstanding feature was the remarkably accurate way in which the erection of the parts proceeded. The construction of these ships was certainly expedited by the adoption of merchant practices in their construction, and perhaps more could have been done in this direction. Nevertheless, the Admiralty allowed considerable latitude as regards details, and modifications to meet yard facilities were always sympathetically considered. The use of welding was encouraged, and one yard completed "River" class corvettes with all-welded shell plating. Here the end connections were butt welded and the seams overlapped; an excellent job was produced in this way and one which proved effective in service.

It had been pointed out in the paper that whilst in the "Flower" class corvettes the scantlings adopted were substantially those of the prototype whale catcher, those of the later ships conformed to Admiralty practice. These light scantlings could only be used in ships operating under certain conditions and where the saving of weight was of paramount importance; they could not be adopted in merchant ships. Nevertheless, they had become familiar to merchant shipbuilders and the classification surveyors through this programme, and must colour previous opinions of what were absolute minima in certain directions.

Structurally, the ships gave little trouble, the only weakness revealed being a slight lack of strength against pounding which caused distortion at a point further aft than was usual in merchant ships, and a slight tendency of the ship to strain at the break of the forecastle. But it was not difficult to cure these slight deficiencies. It seemed to him that the design of the frigates would have been improved if the forecastle deck had been carried right aft to the stern. This would have improved the structure of the ship, provided more space internally and given a drier ship aft. Although he was not on any of these ships in anything approaching heavy weather, even in moderate seas it appeared to him that the after deck was too close to the stern wave for comfort.

Mr. R. W. L. Gawn said that the conception of acceleration as a yardstick for ship motion introduced by the author was most useful. It correlated the separate and combined effects of pitch, heave and roll, both as to amplitude and period. It also gave a ready assessment of the effects of different motions on fighting efficiency both as regards personnel and material. Records of pitch and heave during rough weather model experiments indicated that under the most severe conditions of synchronous motion in steep seas, the extreme acceleration might approach $\frac{3}{4}g$. at bow and stern, the amplitude of pitch being about 5 deg., and heave about 6ft. In moderate conditions, the motion was greatly reduced, but the figures spoke for themselves as to the severity of movement of small ships in the Atlantic forced by war conditions to maintain course and speed on convoy duty in all weathers. Sustained accelerations of only about one-tenth of g., especially when irregular and changing rapidly, were uncomfortable, and one-fifteenth g. was distinctly so.

With regard to propeller singing, which proved a nuisance as the number of corvettes on service increased, he said that a large number of the ships were free, but singing of a borderline character occurred on a proportion of the ships generally with maximum intensity at about one-third full power revolutions. Since the after lines were fine and the wake moderate, and therefore not unduly mixed, it was clear that the trouble was inherent in the propeller design. The persistence of a unique singing note was a menace in that it would lead to the detection of the corvettes and the convoy. The propellers were quickly modified to designs produced at Haslar, with satisfactory results.

Mr. T. C. Grisenthwaite confined his remarks to the "Loch" class, on which he was responsible under the British Constructional Steelwork Association for the preparation of the constructional steelwork drawings, and that part of the shop inspection dealing with the accurate fitting together of the components of the prefabricated units. He emphasised what had been said by previous speakers as to the valuable team work that was carried out, and said that the method adopted was only a feasible and economic solution where a large number of similar vessels were required to be built and where the prefabricated units had to be made by firms with little or no experience in shipbuilding. There were many differences in the technique of work between shipbuilders and constructional engineers particularly in the type of drawings and templates used. Previous schemes of prefabricated ship work had been carried out, but these usually consisted of single plates or built-up sections made from fully-dimensioned drawings on which the position of every rivet hole was accurately dimensioned. But it was soon apparent that the vast number of drawings required could never be produced in adequate time if this method were adopted. Messrs. Henry Robb, of Leith, undertook the manufacture of all the necessary templates from the drawings prepared by the constructional engineers, and no praise could be too high for this important work. The constructional side of the drawing-office was commenced in January, 1943, and in two months it had grown to twenty-five draughtsmen with an equal number of shipbuilding draughtsmen working alongside. No fewer than 411 fully detailed drawings were required, and they were produced in about six months, sent to the template loft and on to the various contractors. Actually, there were 1360 prefabricated units for each vessel, and altogether nearly 100 contractors were engaged in the programme. Bulkheads were fitted complete with watertight doors, ladders, &c., and deck units with hatches and deck treads welded on. The sloping keel section had the rudder bearing incorporated in the unit. The production of the units, which were largely of welded construction, necessitated substantial jigs, particularly for the keel sections. Although every unit had to be accurate to the dimensions and connections shown on the drawings, a certain amount of latitude was allowed in the detail construction to suit the plant of each firm. For instance, deck beams were generally of the flanged L section, with the toe welded to the deck. Firms who could not cold flange the plates made up an L section of two plates welded together. It was only natural that in a scheme of this magnitude, carried out under such conditions, mistakes were bound to occur, but such errors were of a minor character and were readily rectified at the shipyard.

Finally, Mr. Grisenthwaite made the following suggestions for improvement should it ever be necessary to carry out again a similar undertaking:—

Central drawing-office, template loft and building of prototype to be at one site; absolute uniformity of frame spacing throughout the vessel; all units not to exceed dimensions of the usual type of railway wagons available, as outsize units require special wagons involving delays in transport; absolute minimum number of thicknesses of plates and sections consistent with weight requirements; plates to be of the same width in as many cases as possible to relieve delays and sorting out at steel mills; work on actual construction to be delayed at shipyard until adequate supplies of units were available; light partitions and minor bulkheads of a flimsy nature are unsuitable for railway transport and can best be made at shipyards.

Mr. Watson promised his reply in writing.

The last paper was on "Coastal Force Design," by W. J. Holt.

Sir Charles Lillicrap, commenting on the remark in the paper that during the war very few British engines were used in these craft—Italian engines were first used and later mainly American—Sir Charles said that in future we must be more self sufficient; our staff requirements must be related to our industrial capacity, and our industrial thought must in some measure bear relation to

possible wartime requirements. In future it would be no good building boats if we could not propel them.

Sir Stanley Goodall said that, reading between the lines of this paper, it was apparent that there had been a great struggle to make bricks with inadequate straw, and that as regards engines what was wanted was a high-powered, lightweight diesel, because the petrol engine had serious drawbacks. Again, there were great difficulties with materials. They had to rely on wood, and this put a stop to real development. Aluminium was out of court, because it was all required for the R.A.F., and steel was also unobtainable because of the demands for other craft. He felt that this paper should provoke thought on policy. Before the war, the policy with regard to the production of M.T.B.s was similar to that followed by the Admiralty in the early days of destroyers. We relied on private firms in competition with one another to produce the best design. That policy, however, was not really applicable to M.T.B.s, because whereas in the old days the builders of destroyers got their return not only from the Admiralty but from foreign buyers also, there were few orders from foreign countries for M.T.B.s, and the few orders from the Admiralty were not sufficient to justify the expense which the firms would have had to incur on the necessary research and development. To have produced the ideal craft would have cost private firms from £500,000 to £1,000,000 in development and research, and therefore it seemed to him that the only way to proceed in the future was for the Government to undertake such research and development. For this reason, it was a great pleasure to him when he heard the First Sea Lord say, at the Institute of Marine Engineers the other night, that the Admiralty were experimenting on the gas turbine for coastal craft. During the last war we pulled through in spite of all the criticisms that had been heard, but we were not always bound to be lucky, and we ought to take this lesson to heart which was that research and development were essential if, when war came, real producton was to be achieved.

Mr. R. W. L. Gawn said the large fleet of small high-speed craft of diverse types produced at high priority during the war called for a large number of model experiments. Indeed, more than fifty hulls were tested, and some of them were modified two or three times. One problem was to combine good endurance at cruising speed with maximum speed, and this was complicated, especially for the shorter classes of M.T.B. In order to obtain a speed of 40 knots it was necessary to develop dynamic lift. This could be done by a chine, with or without a step. These features promoted wave making and eddy resistance which reacted on the performance at cruising speed, and the effect was considerable, since the cruising speeds were greater, proportionately, than the full speed of destroyers. The displacement was three times as great as that of a destroyer in relation to the length, so that the wave making was increased proportionately. Full speed of the larger types was limited to 35 knots or less by the engine power available. Dynamic lift was then comparatively unimportant, and the form was preferably of round bilge type comparable to destroyers, although the transom was necessarily large for the best results at full speed. Some compromise must, therefore, be accepted.

An important problem for the model experiments was the correction for skin friction, and this was complicated by dynamic lift. The pitfalls of cavitation, too, were wide and deep for the designer of propellers for Coastal Force Craft. The propellers were only just below the water surface, and the tip speed might be as great as 150 to 200 knots. The stagnation pressure was 30 to 50 atmospheres, which suggested that large peak suctions might obtain at the backs of the blades. Propeller design was circumscribed by many factors, and in the early days of the war guidance as to the allowance for cavitation was obtained from the few trial results available. Some of these results left much to be desired as regards accuracy, but during the war improvements were effected in the method of obtaining trial records and predictions of the cavitation factors were progressively refined in consequence. The completion of the cavitation tunnel in 1942 was a great boon. One of the first fruits was an increase of speed of 4 knots in one class by improved design of propeller, one feature of which was two blades instead of three. The cavitation tunnel prediction was confirmed by trials a few months later, the increase in speed being 3¾ knots. The severity of cavitation would be appreciated by the fact that speed trial analysis showed a thrust cavitation factor of two or more was common at one time; in an extreme case a factor of five was recorded. A factor of two implied that the propeller thrust was only one-half that which could be obtained from a propeller sufficiently immersed to eliminate cavitation. Fortunately, the torque was also reduced by cavitation, but a loss of efficiency of about 15 per cent was not uncommon. In later designs, the factor had been reduced and efficiency improved.

A major bugbear arose with the introduction of supercharged engines. The power curves were conditioned by the maximum permissible boost at high speed, but this was only available in short bursts. The power was reduced at maximum continuous boost. If propellers were designed for the full boost to obtain maximum speed, overboosting might result at some lower speed. If the full boost was not used, speed would be sacrificed. The propeller design must strike a nice balance to suit all operational conditions. In some cases, the engines overboosted and in others underboosted, although conditions were nominally similar. This reflected on the propellers. Fortunately, they could be accurately checked on a machine already installed at Haslar for measuring model propellers. As a result it was found necessary to specify precision propellers. A greatly improved standard was obtained, thanks to the whole-hearted co-operation of propeller manufacturers, who worked to fine tolerances without disturbance of their heavy production programme. The controllable pitch propeller was one answer to the requirement for boost equalisation between the different shafts of a boat, and for boost grading at all speeds and loading of hull on service. The first model experiments showed serious loss of efficiency compared with fixed blades. Later designs, however, had been improved, but there was scope for further improvement if sacrifice of full speed was to be avoided.

The author also promised his reply in writing.

(To be continued)

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LOCOMOTIVE BOILER PRESSURE

SIR,—With reference to Mr. E. B. Parker's letter in your issue of March 28th, I am afraid that my statements of December 28th have been misconstrued.

In my paragraph 3, which is apparently the bone of contention, no mention of the use of roller bearings for the parts under discussion was made, but is, as stated, an example of weight saving.* These parts are made from molybdenum steel (Timken High Dynamic), the use of which has brought about a general reduction in sectional area, thereby effecting a reduction in weight without sacrificing strength or safety. The composition and properties of this metal may be of interest to readers, and I append the necessary data:—

Carbon	0·35–0·45 ...	Yield point	120,000 lb
Chromium	0·60–0·80 ...	Elongation	18–20 per cent
Nickel	1·50–2·00 ...	Reduction	55 per cent
Molybdenum	0·20–0·30 ...	Brinell	290–310
Manganese	0·60–0·80 ...		50–70

Further to W. A. Tuplin's reply to my statement, I am rather surprised at the veiled suggestion that increased boiler pressure is a case of fashion for fashion's sake. No self-respecting motive power engineer would indulge in this hobby.

At the annual meeting of the Mechanical Division of American Railroads in 1938, there was insufficient evidence to assess the comparative costs of operating and maintaining high pressure boilers with their low pressure counterparts.

From the increasing number of railways using high pressure boilers in 1946, it is evident that the general overheads incurred are such that an increase in pressure is a desirable feature. Among the numerous American railways using locomotives with high boiler pressure may be mentioned the following:—

The Pennsylvania R.R.
The Atchison Topeka and Santa Fe R.R.
The New York Central R.R.
The Kansas City Southern R.R.
The Norfolk and Western R.R.

The latter railway is using a considerable number of 2–8–8–2 compound mallet locomotives with boiler pressed to 300 lbs per square inch.

One important thing necessary to obtain the full benefit of high pressure is a steam distribution valve giving a cut-off at a low percentage of the stroke, and this can be obtained by the development and eventual use of a double ported valve and also the poppet valve. The latter is being used to some extent by the Pennsylvania Railroad in their Class "T.I." 4–4–4–4 high speed passenger locomotives, following extensive trials on a K.43 "Pacific" type locomotive and two prototype 4–4–4–4 locomotives.

This gear is being developed by the Franklin Railway Supply Company, Inc., and the Associated Locomotive Equipment, Ltd., of London.

ARTHUR H. GRAHAM.

London, S.W.11, March 29th.

* *Sic* ED. THE E.

TOTAL, NOT PARTIAL, CO-OPERATION

SIR,—In the report of the Institution of Mechanical Engineers in your issue of April 4th, there is a reference to the Conference of Commonwealth Engineering Institutes. In this conference the Institution of Civil Engi-

neers, the Institution of Electrical Engineers, and the Institution of Mechanical Engineers took part. This meeting, says the report, "marked an important step in the evolution of engineering institutions in the British Commonwealth, and all those who participated have paid tribute to the value of the discussions." This is all satisfactory as far as it goes, but it leaves out of account the multitude of professional engineering institutions. This attitude cannot be permanently satisfactory.

We might take a leaf out of the book of the United Nations Organisation. In the constitution of the Security Council, which decides the issues of peace or war, not only are there five permanent representatives of the big powers, but also six representatives for periods of the smaller powers.

To ignore interested parties is out of tune with the spirit of the new era.

It is to the good that the Automobile Engineers are about to combine with the Mechanical Engineers; the decision was reached by a vote of 2 to 1.

There are many similar cases in the professional world where amalgamation is desirable.

A. W. Crampton, F.S.I.

London, N.W.6, April 10th.

RAILWAY ROLLING STOCK

Sir,—I should like to supplement the letter of "Progressive," in your issue of March 14th, on the design of railway goods rolling stock for the bulk carriage of granular materials such as coal, coke, iron ore, &c.

Whilst agreeing with many of "Progressive's" points on the inadequacy of rolling stock for a great number of bulk unloading installations, he should not neglect the large field opened by the introduction of the "Pusher type" mechanical truck discharger mounted on an excavator chassis. This type of unloader has a mobility feature in that the material can be discharged over a wide area in contrast to the wagon tippler or bogie hopper wagon to which so much of "Progressive's" attention was devoted.

The requirements of this equipment with regard to rolling stock are simple in the extreme, providing the principle of side discharge is preserved. Obviously the best type of truck for quick and economical discharge with this equipment is the full falling door type or with a falling door made in two or more parts. A 20-ton wagon is of convenient size, but other sizes make little or no difference to the unloading rate. With this type of wagon an hourly discharge rate of 300 tons per hour, per machine, can be maintained.

Naturally, the discharging efficiency varies with wagon type and practically every type of wagon has been tried on some occasion. The "pigeon-hole" design of wagon requires more skilful operation of the equipment, particularly when the aperture is extremely small; however, a discharge rate of 90 tons per hour can be maintained.

The greatest quantity of rolling stock is distributed into small yards and sidings, where it would be impossible to arrange for undertrack hoppers for bottom discharge wagons carrying bulk materials, but where some alternative to hand labour is imperative on the score of economy.

If, then, as is now evident, new types of rolling stock are being considered, I do think that this type of mechanical unloading should not be neglected, since it represents the cheapest method of unloading what must be the simplest type of truck. While improvements in braking, unladen weight and couplings are long overdue, I feel that developments should be on the lines of the larger flat-bottomed drop side wagons for general purposes, with a small special requirement for hopper wagons.

"Dianthus."

April 3rd.

CONDENSATION BY COMPRESSION

Sir,—I fear that Mr. Holcroft has not elucidated the mystery. The "system" shows an obvious improvement due to hot closed feed:—

	Atmospheric Working	"On system"
Heat in steam	1197 ...	1197
Temperature of feed	50 ...	228
Heat in feed	18 ...	196
Heat put in by boiler	1197 ...	1001
Saving by "system"	— ...	178
		or 15·1 per cent.

Now there is no magic or mystery about this. But Mr. Holcroft says that each pound of feed on the "system" contains 497 B.Th.U.

At 6 p.s.i.g. we have

Sensible heat	198
Latent heat	959
Liquid entropy	0·339
Evaporation entropy	1·391

So that the "system" feed consists of

$$\frac{497-198}{959}=0\cdot312 \text{ lb steam and } 0\cdot688 \text{ lb water.}$$

Therefore the entropy of the feed was

$$0\cdot339+(1\cdot391\times0\cdot312)=0\cdot773.$$

Now at 155 p.s.i.g.

Saturation temperature	368
Sensible heat	341
Latent heat	856
Liquid entropy	0·526
Evaporation entropy	1·034

Therefore the compressed feed will consist of

$$\frac{0\cdot773-0\cdot526}{1\cdot034}=0\cdot239 \text{ lb steam and } 0\cdot761 \text{ lb water.}$$

This will have a heat content of

$$341+(856\times0\cdot239)=546.$$

The feed therefore suffers a heat rise of 546—497=49.

Mr. Holcroft gives the available adiabatic heat drop "on the system" of 154·5.

Therefore an ideal feed compressor must have called for 32 per cent of the gross power output. Whereas Mr. Holcroft says it only took 3½ per cent. Dare one suggest an error in the decimal point?

Clausius set out the second law of thermodynamics in the following simple terms: "Heat cannot of itself pass from a colder to a hotter body." Consequently, one finds great difficulty in swallowing "the inventors manipulation of this endless stream of energy so that it passes through its various phases without change of energy, like a wave."

May I suggest that "the system" obviously gave a 15 per cent improvement due to feed heating and that measurement of coal fired was insufficiently accurate for such a test.

Mr. Holcroft's Sankey diagrams are very beautiful, and I wish I could believe them, but I fear they cannot be true.

Oliver Lyle.

London, E.16, March 24th.

Sir,—Mr. Holcroft has made a courageous attempt to answer the criticisms arising from his article bearing the above title, but it is to be feared that his alleged balance sheet, appearing in your issue of March 21st, will hardly satisfy his critics. All that he has done, in fact, is to calculate from the very few useful figures obtained in the tests the corresponding heat quantities and to use these as a basis on which the remaining—and most important—items are obtained by difference; these items are the heat rejected and the heat to be supplied to the feed, which are the crucial terms giving rise to the present controversy. In the circumstances it is hardly surprising that his figures "balance out."

Mr. Holcroft's latest letter, however, contains at least one very interesting admission; referring to the action of the "compressor" or steam pump, he states (quoting Mr. Anderson) ". . . until the piston is nearly at the end of its stroke and *the contents have been reduced to liquid form.*" We think, if he now attempts to trace the behaviour of the working fluid throughout a complete cycle on a temperature-entropy diagram he will find there is very little difference between his cycle and that of Rankine.

For the conditions of the tests described by Mr. Holcroft, a comparison of the latter cycle with one based on "atmospheric" or cold feed working shows that the heat to be supplied to the fluid in the boiler is 1000 and 1179 B.Th.U./lb, respectively, in the two instances. This would mean a saving in fuel of about 18 per cent. Actually, if the pump functioned partially as a compressor, the saving would be slightly more than this, as the analysis in a previous letter from one of us (S.L., October, 1946) shows. However, the potential saving is still well below the figure claimed by Mr. Holcroft, and we suggest that the difference is probably due to the shortness of the test periods which would hardly allow equilibrium conditions, particularly in the boiler, with its relatively large heat hold-up capacity, to be attained.

F. P. Frost.
S. Labrow.

Stockton-on-Tees, April 9th.

SCIENCE AND INDUSTRY

Sir,—It would appear from your editorial of March 21st that in my letter to *The Times* of the 13th I had not made myself sufficiently clear in my main thesis, the need to rely more on the scientific resources of this country to get us out of our present difficulties. Up till then, practically all discussions of this question had concentrated on economic and administrative and not scientific and technical factors. I felt that science—in the widest sense—was absolutely essential to get a greater production of goods and services from our very limited material and human resources. Naturally, however, not myself being an engineer, I concentrated in the latter part of my letter on the contribution that could be made by scientists who are normally occupied with fundamental work.

Now, of course, it was impossible in a letter of that length to explain more precisely what that contribution could be. In effect, however, I referred to it in mentioning the development of radar and of operational research, largely as likely to be most familiar to my readers. In the course of six years' war experience, I have seen enough of the way in which scientists and engineers can work together, to know the value of their respective contributions and the much greater value that could be obtained when they worked together closely for definite objectives. This was the case, for instance, in such largely engineering enterprises as the Mulberry Harbour. But, and I think this is the new point brought out by our war experience, such collaboration, to be really fruitful, has to be organised on the widest scale. It has, in the phrase of Sir Henry Tizard, to have its Strategy as well as its Tactics.

In dealing with such a problem, for example, as the best utilisation of fuel and power, it is necessary to co-ordinate on a high level not only the fuel producers and the direct fuel users, both domestic and industrial, but also the users of the products for which the fuel is used. However efficient any production process is in detail, it may, looked at in the general productive framework, take a disproportionate amount of scarce resources.

Now these strategy questions have in the past been left to economists. My plea is that

their scientific and technical aspects should also be taken into account. For instance, the development of blended cements might economise considerable quantities of coal and still provide enough material to prevent shortages in construction. Such work, moreover, will necessitate a certain amount of scientific testing and engineering development which would not be undertaken unless there was some drive in the national interest to see that it was done.

The method "not already in use," which I am advocating, is the method of operational research, which was used so successfully, for instance, by Professor Blackett, in dealing with the U-boat war, and Dr. Gordon in the institution of planned flying. The method was first to make a broad survey very rapidly to discover those points by which, with the smallest effort, important successes could be achieved in a relatively short time, then to concentrate all technical and scientific resources at these points, together with a continuous check on the success of the individual measures. This is not always the method by which we would work in long term planning, but my point is that the situation we are in at present justifies a concentration of effort of this kind, using for the job every keen and competent man, whether he be engineer or scientist in any sense.

Naturally, as a scientist, it would be absurd for me to attempt to indicate in advance of survey what particular problems could be tackled by these methods, and what the results would be. My case is that as these methods have shown notable success in practical fields during the war, there is every reason to suppose that they would be at least as successful in peace. I am fully aware of the differences between wartime and peacetime conditions, but the leading characteristic of operational research methods is that they take the actual administrative and economic conditions fully into account, and can adapt themselves to a wide variety of administrative set-ups. To suggest these methods is not in any way to depreciate the value of the work, both scientific and technical, carried out by British engineers at the present time. It is only to suggest that a greater degree of integration would mean that this work could proceed more smoothly and more rapidly.

I was somewhat surprised to find the reference in your editorial to my "proposed Committee of State Scientists." The body I actually referred to was the recently appointed Tizard Committee, which contains a carefully balanced and consequently deliberately heterogeneous selection of scientists chosen on account of their proved success in coping with the practical problems of wartime. They include three scientists in the broad sense, who are themselves engineers of distinction, Sir Reginald Stradling, F.R.S., Sir Ewart Smith and Sir Claude Gibb. The quality of the Committee is therefore one to give every confidence in their performance. The purpose of my letter was to urge that they should be given as free a hand as possible and not hampered by administrative restrictions, in which desire I am sure I have the support of the vast number of engineers in this country.

J. D. Bernal.

London, E.C.4, April 2, 1947.

LOCOMOTIVE VALVE GEARS

Sir,—Mr. K. N. Harris's last letter on this subject brings out no new facts, but merely underlines his faith in certain legends. He asks: "If so and so and so and so, why do the G.W.R. people do so and so?" A query of this sort is surely better directed to the people with authority to answer it than to readers in general.

He repeats, apparently as an argument, the old story that "Churchward always preferred Stephenson's gear . . ." Whether that is true or not, the important fact is that the excellent cylinder performance achieved with Churchward's Stephenson gear is surpassed by that achieved with Churchward's Walschaerts gear. After a distinguished designer has done his best with both (and is even said to *prefer* the Stephenson gear) the Walschaerts gear wins.

I do suggest that discussion should be based on demonstrable facts, rather than on assumptions, surmises, views or preferences, even of "authorities." Established practices in mechanical engineering are rarely due solely to technical considerations, and so for that reason, if for no other, it is never safe to argue that because somebody always does something it must be right. Neither is any useful purpose served by judging a mechanism on particular designs that are as inexcusable as polygonal wheels.

W. A. Tuplin.

Huddersfield, April 11th.

Radio Equipment for a Canadian Power System

Power development for the central section of Vancouver Island centres around Elk Falls—a part of British Columbia's famous Campbell River. This river is the natural draining agent of a large section of the central area of Vancouver Island. From the higher hills the stream turns northward, draining into Buttle Lake. This lake, which is twenty-one miles long and three miles wide, is fed by all the glaciers of Strathcona Park, and from it emerges the Upper Campbell River. At Campbell Lake this water is joined by the Elk River, a considerable stream, which in ancient times afforded a route for the Indians travelling from Vancouver Island to the mainland. Elk River merges with the Campbell, but gives its name to Elk Falls, site of the new B.C. Power Commission power plant. Here is situated the best natural power site on the island, capable of developing in excess of 100,000 horsepower.

When legislation was enacted bringing the B.C. Power Commission into being, a vote of ten million dollars was passed to initiate the scheme. One of the first steps of the newly formed Commission was to take over the Nanaimo-Duncan Utilities, thus forming the nucleus of a distributing system, with centres at Nanaimo, Duncan and Alberni. The power from Elk Falls will be fed to the distributing system by means of a high voltage transmission line, using steel tower construction. This line will be parallel to the coastline and, at some points, is ten miles inland. The terrain over which the line wanders is, in places, over 3000ft high and is subjected to winter gales, which reach velocities of sixty to seventy miles per hour.

Radio Control System

In order that this transmission line could be properly maintained and, especially, repaired in the event of breakdown, the Commission decided to install a modern frequency-modulation radio system at all key points and gave the contract for the work to the Canadian Marconi Company. Work is now under way on this radio system. It will provide communication between the main powerhouse at Elk Falls and the sub-station at Nanaimo, and a channel for telemetering and cathode ray tube synchronisation of generators at Elk Falls and Alberni. Owing to the high cost of tapping the high voltage transmission line—about 150,000 dollars—only two taps will be made between Nanaimo and Elk Falls. One of these will be in the Comox area, and the tap for the Alberni area will be at Qualicum, about twenty-five miles north of Nanaimo.

The Nanaimo control station is situated at the 1000ft level on the east slope of Mount Benson (3400ft high), three miles west of Nanaimo. At this station, a DJ-21 250-W transmitter-receiver, working on 39·02 megacycles will be installed, and also a QJ-11 receiver, working on 35·54 megacycles. The latter equipment will receive signals from the repeater station at Fanny Bay. Two 70ft masts will support the antenna; one will be a coaxial halfwave for the DJ-21 and the other a quarter-wave ground plane antenna for the QJ-11. This apparatus will be controlled from the substation, which is approximately one mile north-east. Marconi remote control units will be used for this purpose.

Transmission to Elk Falls, eighty-three miles away, and Alberni, thirty-eight miles, will be direct, and to the Commission's mobile units when they are within forty miles. Reception from Elk Falls and to mobile units within twenty-five miles will be direct. From Alberni and to the mobile units within twenty-five miles of the Fanny Bay area, reception will be through the repeater station, thirty-five miles north of Nanaimo. The Elk Falls station is situated at the gates to the intake flumes, approximately one mile west of the Falls and power station, at the 500ft level. The equipment duplicates that installed at Nanaimo with the remote control units in the control room of the main power house. The Alberni station will be in the town of Port Alberni, on a knoll about 300ft above sea level. There will be a DJ-11 Marconi FB 60-W transmitter-receiver working on a frequency of 39·02 megacycles. There will be one 70ft mast supporting a half-wave co-axial antenna. Remote control equipment will be similar to that at Nanaimo and will be mounted in the control room of the power house, which is approximately four miles north-east. For the time being three mobile units (2-ton trucks) will be equipped with Marconi FM apparatus.

Repeater equipment will be one FT-12/QT-11 mobile unit receiving on 39·02 megacycles and controlling the transmitter automatically on 35·54 megacycles. Power supply will be by two 180 amperehour storage batteries connected in parallel, which will float-charge from the rural power line, which is 110 V 25 cycle a.c. Two masts will be erected when a permanent site is selected. They will be 70ft high and will support one co-axial half-wave antenna for transmitting and a quarter-wave ground plane antenna for reception.

The Royal Netherlands Industries Fair

The forty-eighth Royal Netherlands Industries Fair, which opened at Utrecht at nine o'clock on Tuesday morning, April 15th, and remains open until Thursday, April 24th, is the largest of any fairs held since the Utrecht Fair was started in 1917. For the first time all technical exhibits are housed in twelve buildings and many open spaces on the Croeselaan site, leaving the Vredenburg site for the more general exhibits. There are 2514 exhibitors at the 1947 Fair, taking up 33,815 square metres of space. These figures compare with 2009 exhibitors and a space of 32,120 square metres at the previous Fair. Of the 2514 exhibitors this year, 1134, or about 45 per cent, are foreign firms or their Dutch representatives, The international character of the Fair is shown by the following figures for each country's exhibitors:—The Netherlands, 1380; Great Britain, 268; United States of America, 201; Switzerland, 148; Belgium, 147; France, 137; Czecho-Slovakia, 118; Sweden, 32; Denmark, 29; Italy, 20; Germany, 8; Canada, 7; Austria, 6; Luxemburg, 3; Norway, 3; Hungary, 2; Egypt, 2; and one exhibitor each from Australia, Portugal and Palestine. Several countries have their own national sections. Great credit is due to the exhibition authorities for the hard work they have put into the new buildings in order to finish them in time for the Fair. Work could only begin in frost and snow on February 24th. Two wooden buildings ordered from Sweden about that time and since completed have not yet been delivered owing to difficulties of transport.

Adaptation of Concrete Mixers for Other Work

WE have received from Winget, Ltd., of Rochester, particulars of some interesting applications for which various types and sizes of the firm's well-known range of concrete mixers have been adapted during recent years. Although most of the processes involved are entirely divorced from the work for which these machines were primarily designed, their capacity for producing an intense mix of contrasting constituents, and their rapidity of operation, has made them, after relatively minor modification, suitable for processing many other materials. The designers of these machines have shown how what are basically concrete mixers can be successfully adapted for the processing and mixing of materials in the manufacture of electric batteries, explosives, paints, glass and certain foodstuffs. From early conversions of concrete mixers a rotary furnace has now been evolved which is being used in the reclamation of aluminium and other types of non-ferrous swarf and scrap. From the many industrial uses for which Winget concrete mixers have been adapted, we have selected three for purposes of illustration.

The photograph reproduced in Fig. 1 shows one of a battery of half cubic yard, tilting drum mixers now being used for the mixing of ingredients in the works of a large firm of electric battery manufacturers. As one of the ingredients is a highly corrosive acid, special precautions have to be taken during mixing and the drum is lined with ¼in thick cab tyre quality rubber. The drum is charged with the carefully proportioned constituents from a platform at the rear of the machine, its mouth is then covered with a rubber-lined wooden lid to prevent splashing of the contents during mixing. When the mixing process is completed the drum is swung over, away from the loading platform, to discharge the mixture into rubber-lined trucks. As can be seen from the illustration, the steep angle of discharge, combined with the large mouth of the drum, enables the rapid and complete discharge of all the contents. The dangerous nature of the mixture and the fact that it has on occasions to be discharged in relatively small quantities, necessitates the adoption of special tilting gear. This gear comprises a ½ h.p. reversible motor running at 1400 r.p.m., which tilts the drum *via* an under-driven worm gear; the coupling between the two units incorporates the brake drum for a magnetic brake reduction unit controlled by four limit switches, set for loading, mixing and a variable discharge. All controls are grouped on a panel on the loading platform in a position where they can be operated without danger to the attendant during the mixing and when tilting and emptying the drum.

We are informed that a smaller mixer, fitted with special shields, electrically driven, and with a chromium-plated drum, was used during the war in the manufacture of food tablets for the armed forces. A similar machine, having a steam-heated drum, was also used in the manufacture of high explosive materials. Heated drum mixers have been used in processing work by manufacturers of gelatine and starch.

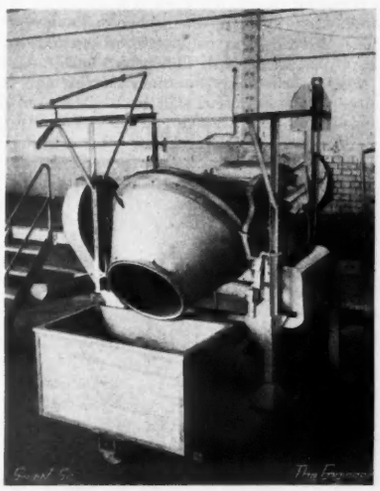


FIG. 1—MIXER FOR ELECTRIC BATTERY INGREDIENTS

The success of mixing concrete depends on the degree of intimacy achieved and action on every individual particle of material fed into the drum. This intensive action has been applied with marked success to the cleaning of small castings, nails, and other like articles by using concrete mixers for rumbling.

All the above applications are connected with the tilting drum mixers, which are generally the more adaptable type. But we are informed that non-tilting drum mixers have been used successfully both as washers and mixers of various materials, such as glass and magnesium.

The Winget ½-ton capacity rotary furnace, designed for the melting and recovery of aluminium swarf, which is illustrated in Fig. 2, shows the close relationship between the orthodox stationary concrete mixer and the rotary tilting furnace. The furnace bowl, which has a slightly elongated and much stouter version of the tilting drum mixer bowl, is lined with a straightforward high alumina refractory brick (specially made for the job), and thus the standard mixer design is converted into an efficient rotary furnace.

The frame in which the drum rotates is supported on trunnions, and tilting is effected by hand-wheel and reduction gear, which, in turn, is controlled by a powerful band brake, operated by a pedal. This brake is designed to hold the drum rigidly at any angle and to prevent the accidental tilting of the drum when charged with molten metal. A wide air gap between the frame and the drum provides effective heat insulation, the only points of contact being the supporting rollers, the bevel gear drive, and the bottom locating shaft. In operation, the rotating furnace is charged by hand with a mixture of the chosen flux and prepared waste; at first the mouth is set low, as illustrated. As the level of the molten metal in the furnace rises, the drum is tilted backwards, and charging proceeds until the furnace capacity of about 1200 lb of molten aluminium is reached. The large furnace mouth permits easy charging with even the lightest swarf, and the adhesive layer of molten metal and flux adhering to the sides of the rotating furnace prevents the loss or escape of the smallest particles fed in, whilst the rotating motion of the furnace plunges the light particles of metal into the molten mass, where they are quickly converted. Pouring temperatures of many of the non-ferrous materials are very critical, and the rapid, positive action geared tilting mechanism, coupled with the large furnace mouth, makes it possible to ingot the charge quickly with little or no drop in temperature.

The Winget-Morgan crucible rotary furnace, to be seen in Fig. 3, clearly shows the method by which the crucible and burner are fitted, and here, again, plunging action produced by the rotating crucible has the same effect as occurs in the larger open furnace, *i.e.*, as the material is fed into the crucible it is immediately submerged away from the atmosphere. In this case the refractory-lined drum has a larger mouth than usual to accommodate the crucible, and a heavy stationary head-shield for conserving heat is supported on the stationary members of the tilting frame. A hole in one side of the head is in line with a high-pressure burner, which projects its flame down between the sides of the rotating drum and the crucible. On the head is a bracket supporting the filling-chute to the crucible. As with the rotary furnace, described above, the furnace is steadily tilted backwards until the crucible is filled to its maximum capacity, which is about 600–1000 lb of molten brass or copper. The head, burner and filling funnel can be rapidly swung clear when it is required to remove the crucible.

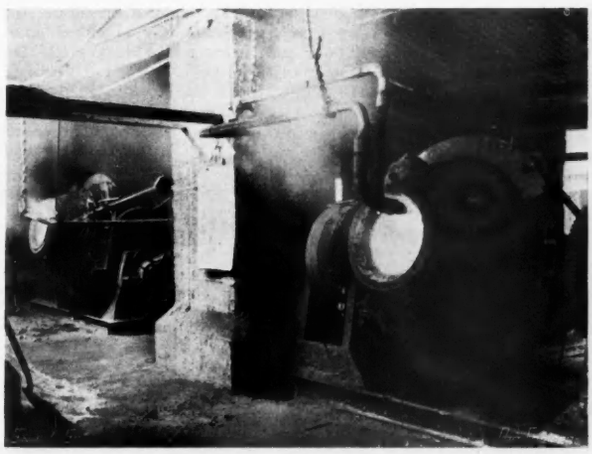


FIG. 2—HALF-TON ROTARY FURNACE

FIG. 3—CRUCIBLE ROTARY FURNACE

Cold-Starting Internal Combustion Engines

On January 22nd the North-Western Centre of the Institution of Automobile Engineers held a meeting at Leyland Motors, Ltd., at which Mr. R. Barrington, M.Sc. (research engineer, Joseph Lucas, Ltd.), Mr. W. A. Bevis, B.Sc. (electrical development engineer, C.A.V., Ltd.), and Mr. K. Brook (chief diesel engineer, C.A.V., Ltd.), read a paper, entitled "Recent Developments in Low-Temperature Starting of Petrol and Compression Ignition Engines." The paper dealt in detail with research work conducted during the war in connection with the operation of military vehicles.

The result of the work was that reliable starting could be obtained down to temperatures of — 40 deg. Fah. The authors pointed out that the problem, although generally similar for both petrol and compression ignition engines, differed slightly in detail. In the case of the petrol engine, ignition could be obtained at any speed provided that the mixture ratio was appropriate, but in general a minimum speed was necessary to attain this mixture ratio, while at very low temperatures the use of a specially volatile fuel at starting might also be necessary. Special provision was necessary in the case of the carburetter to prevent the surplus and unevaporated fuel from causing over-enrichment when the engine had started.

As regards the viscosity of lubricating oil, the following useful formula had been established:

$$T = K\sqrt{NV},$$

where

T was the crankshaft torque in lb per foot,
N was the speed in r.p.m.,
V was the viscosity in absolute units,
K was a constant for the engine, depending partly upon cylinder swept area and influenced by the lubricating qualities of the oil.

For the lower temperatures, oil intentionally diluted with petrol was used, diluted to a maximum of 15 per cent between 0 deg. and —20 deg. Fah., and 25 per cent between —20 deg. and —40 deg. Fah.

In the case of the direct injection oil engine the problem was to obtain the maximum possible cranking speed with a reasonable use of starter motor and battery, and to provide means of enabling the engine to fire by the use of an ignition promoter. The following methods of aiding starting were investigated:—

Electrical heating of the induction air (too great a load on the battery).

Flame heating of the induction air (not successful on four-stroke units).

Retardation of fuel injection (too much modification of standard design necessary).

Modification to injectors (only minor improvements obtainable).

Use of excess fuel (100 per cent increase found very helpful).

Application of an ignition-promoting unit (ether introduced into the induction air during cranking showed great possibilities).

The authors then described the various stages of development in the use of ether until finally a specially designed carburetter was used, fed from a capsule containing 13·5 cc of ether and punctured with a special tool. With this arrangement at 0 deg. Fah. engines cranked at 60 r.p.m. would fire in 3–5 sec., and would be running on fuel only in 60 sec. or less. For lower temperatures it was found necessary to use two capsules consecutively instead of one.

Opening the discussion, Mr. S. Markland, director and chief engineer, Leyland Motors, Ltd., recalled the physical discomfort of the cold rooms in which the research work was carried out, where special protective clothing was necessary. The diesel engine problem was the more difficult, but by the winter of 1941–42 Leyland tanks fitted with the devices described were being sent to Russia. He would like to warn anyone present who might be tempted to experiment with the "dopes" described that they were potential detonators, and if offered at the incorrect rate the engine was just as likely to run backwards as forwards, with disconcerting results. These devices were developed for war use irrespective of cost. Now those present were concerned with commercial development. Did the authors carry on with experiments on the use of gas oil, fired by a trembler coil spark to produce flame in the inlet pipe?

Replying, the authors said that the final version of the ether carburetter almost eliminated detonation and reversed running. They saw no reason why the devices described, if produced for commercial purposes, should be expensive. The spraying of diesel fuel on to a trembler spark was not very successful, and the experiment was dropped. They had shown that smaller but more powerful starter motors could be produced and a lot of work was now going into this problem.

Mr. F. Y. Frazer, chief engineer, Manchester Corporation transport, said that in practice the Manchester system of passing low-pressure steam through the radiators of parked buses had proved successful. They had had hundreds of buses parked in the open during the cold winter of the war and still had. They supplemented the steam heating with radiator muffs if the wind was blowing through the radiators. In Manchester the problem was not starting from cold first thing in the morning, but of batteries running down in service on vehicles running only at peak periods and scarcely out in daylight at all. About 50 per cent of their involuntary stops were due to batteries being run down. The authors replied that it was hoped that future developments of the compensated voltage control system providing the maximum charging at low speeds would take care of this problem.

To another questioner, the reply was given that the ether capsules had cost 2s. 6d. each during the war, calculated presumably on the non-return of the empty capsule.

The Tordera Bridge, Spain

An interesting example of a combination of steel and concrete in a bridge structure is given by the recently completed Tordera Bridge, in the Province of Barcelona, Spain. The bridge, illustrated herewith under construction, provides a roadway, 21ft 6in wide, and two footways, each 3ft 4in wide. It comprises a central span of 178ft and two side spans, each of 148ft. The decking of each span is carried by two fish-bellied trusses, with concrete upper chords, but the lower chords and diagonals are of steel, electrically welded. It is claimed that this composite construction gives an improved adaptation of each material to structural requirements. Our illustration shows an early stage of construction, before the top chords and decking had been concreted.

The lower chords, instead of the usual parabolic shape, are formed to the shape of an elliptic arc, with the object of increasing the slope at the supports and reducing secondary stresses. The diagonals have a box section, formed by welding two channels together, whilst the lower chords are made from steel plate. The vee-shaped diagonal members are noticeable, as is the absence of any transverse bracing of the lower part of the decking. This vee-shape was adopted so as to reduce stress concentrations in the upper joints at the junctions of the diagonal members with the concrete upper chords.

The steel members were erected first and then the upper chords and decking were concreted. With the concrete hardened, the decking acted as the compression flange of the main trusses, after the manner of a tee beam.

As the design was somewhat novel, its behaviour when completed was the subject of a careful check, by noting deformations under various loads. The results are understood to have been in exact accordance with calculations.

The design is due to Professor E. Torroja, Director of the State Testing Laboratory; Mr. J. Lgarde, chief engineer of the Highway Board of Barcelona; and Mr. A. Andreu, engineer of the Highway Board. The contractor for the Spanish Highway Board was the Society Omes, which placed 350 cubic yards of concrete and erected 180 tons of steel to build the bridge.

TORDERA BRIDGE UNDER CONSTRUCTION

Stainless Steel for Rails.—Stainless steel is now being used by London Transport on rails to ensure electrical contact in special situations. An essential feature of the signalling system on London Transport railways is the passage of current from one running rail, through the wheels and axles of trains, to the other rail in order that the presence of trains can be detected. Generally the rails are polished by the frequent passage of trains, but in certain "refuge" sidings which are only used occasionally, the rail surface rusts sufficiently to induce some risk of the wheels not making a good enough electrical contact with the rails to ensure the passage of the signalling current. Although these trains are not in use at such times by passengers a failure of signalling might prove inconvenient in the operating of the sidings, so it is necessary to take measures to ensure the normal functioning of the apparatus. After considerable experiment and investigation, the most suitable means to ensure contact has been found to consist of a thin strip of stainless steel on the top of the rails of sidings. This provision is made by depositing weld metal of suitable composition in a continuous run. Experience covering some eighteen months' service has proved so satisfactory that the scheme is to be extended to ten sidings where rust is likely to occur to a degree warranting attention.

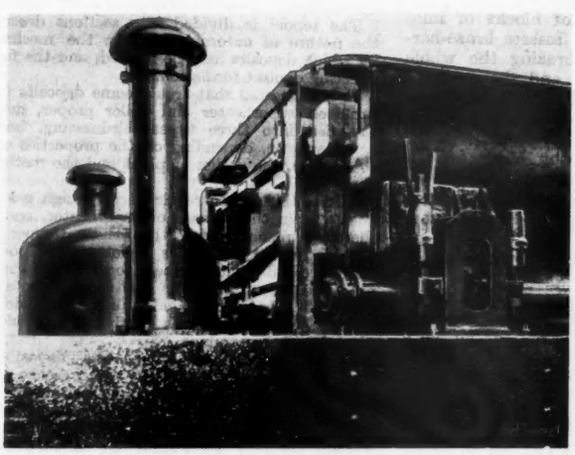
Coal Weighing Tenders on the L.M.S.

OWING to the increased difficulties of coal supply, both of quantity and quality, the checking of coal consumption on railway locomotives has become increasingly important. With a view to a closer study of the methods of firing, the effect on consumption of traffic delays, and other features of present-day operation, together with a closer watch on the effect of the varying qualities of coal, two special coal-weighing tenders have just been completed to the design of Mr. H. G. Ivatt, chief mechanical engineer of the London, Midland and Scottish Railway Company.

A photograph of one of the new tenders is reproduced below. It has underframes, wheels and axle-boxes of the standard 4000 gallon type tender in use on the larger locomotives, but new tanks and coal bunkers have been fitted. These tanks hold 3750 gallons of water, and the bunkers 7¾ tons of coal, as against the 4000 gallons and 9 tons of the standard arrangement. The tenders can be coupled to any standard engine.

The coal-weighing device, which is not intended for use while the engine is in motion, consists of a separate bunker, having vertical sides, with a self-trimming back. It normally rests on six cone seatings on brackets on the tank top and in this position it can be locked, to prevent relative movement and damage to the knife edges of the weighing mechanism. When it is desired to weigh the coal, the locks are released, the load is then transmitted through two shafts running longitudinally along the tender tank top to two main levers situated at the rear of the coal space, and then *via* another lever to a steelyard. The steelyard is calibrated to read directly in tons and quarter cwts by the usual sliding weights, and incorporates means of locking in the weighing position or otherwise, to safeguard the knife edges.

In operation, having ascertained that the bunker is in the correct position and all locks engaged, the tender is coaled in the normal manner. A cover is then removed from the steelyard and its locking devices and those on the bunker are released so that the load is transmitted through the lever system to the steelyard, where the load is measured by adjustment of the large and small weights on the arm. The weighing system is then re-locked in its normal position, the cover is replaced, and the tender is then ready for the road.



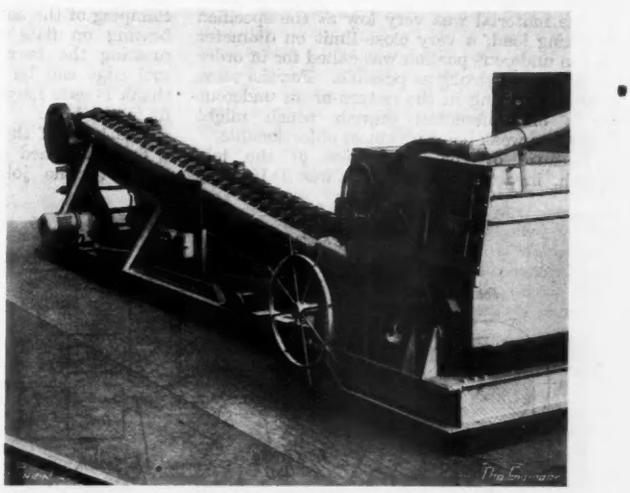
COAL WEIGHING MECHANISM

Locomotive inspectors ride with the engines of these tenders whenever they are working a train, and by use of the weighing equipment, the day's coal consumption can be broken down as desired. With these tenders the amount of coal used for lighting up, shed duties, shunting, while working the train, and during any traffic delays which may occur, can be ascertained quickly and accurately. The variation in consumption due to the best methods of firing and engine working can be demonstrated to the crew and methods can be developed for getting the best results from the lower grades of coal now having to be used.

We are informed that the actual weighing mechanism was manufactured by the Transport and General Engineering Company (Leeds), Ltd.

A Continuous Ingot Casting Machine

A NUMBER of continuous ingot casting machines have been built by Sheppard and Sons, Ltd., of Bridgend, Glam, during the past few years. Each machine is a self-contained unit comprising a fabricated steel chassis and frame, carrying an endless conveyor and ingot moulds, together with a driving unit and an air cooling system. The design is such that one of the machines works in conjunction with one or a number of furnaces and can be readily adapted to a particular melting shop lay-out. The photograph we reproduce shows one of the ingot casting machines arranged to work in conjunction with a Skelnar furnace.



CONTINUOUS INGOT CASTING MACHINE

The conveyor chain comprises two strands of links, each strand being built up of one thick and two thin links arranged alternately. On to the links attachments for the ingot moulds are welded. Extensions to the ends of the link shafts connecting the two strands carry cast iron rollers, which support the conveyor on the main frame. Each roller is mounted on a phosphor-bronze bush incorporating means of lubrication. A spring-loaded device in each roller assembly compensates for the unequal expansion and contraction which takes place between the mould and the spindle whilst the machine is in operation.

The conveyors are made with a standard length between centres of 21ft 3in and each carries seventy-four ingot moulds. Interposed between the moulds, which are made of special iron, and their link attachments are asbestos insulating pads. On each mould a spillage lip is formed, so that, should any be inadvertently overfilled, the surplus metal flows down into the succeeding mould. To facilitate hand skimming of the ingots a lip is cast on one side of each mould.

The conveyor is driven through a shaft mounted in heavy angular plummer blocks at the discharge end. Drive from a 2 h.p. motor is transmitted to the main shaft through a chain, two intermediate shafts and machine-cut gearing. This gearing can be varied to give a fairly wide range of speeds according to the type of metal being handled. All of the driving gear is protected by substantial renewable sheet steel panels. The hexagonal driving drums on the conveyor main shaft are fitted with renewab le steel teeth. The conveyor hauling shaft incorporates screw tensioning gear and is carried in cast iron blocks at the pouring end of the main frame.

A 2 h.p. motor-driven fan supplies between 2000 and 2500 cubic feet of air per minute to the air cooling system of the machine. This air is conveyed through trunking and directed on to the line of returning empty moulds on the lower side of the conveyor. The cooling system is designed to permit the continuous running of the machine without the excessive heating which would be encountered if normal atmospheric cooling was relied upon.

The chassis on which the machine is mounted can be fitted with flanged wheels to run on rails or plain wheels to permit mobility on level flooring. According to the lay-out of the shop and its furnaces, the machine can be designed for longitudinal or transverse movement or both. A power take-off fitted to the conveyor driving gear can be used to impart power for longitudinal movement, and for transverse power drive a small independent motor can be fitted.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

TEST CODE FOR GAS-FIRED WASTE-HEAT AND WATER GAS PLANT BOILERS

No. 1307. This Code covers the testing of gas-fired boilers and waste-heat boilers (with or without auxiliary firing). Special consideration has been given to waste-heat boilers operating on the exhaust of internal combustion engines. It is hoped that through the use of this Code, it will be possible to avoid difficulties and misunderstandings which have hitherto arisen in the correlation and comparison of results obtained in different tests, due to the lack of standard testing procedure and technique. Price 5s.

ARCHITECTS', ENGINEERS' AND SURVEYORS' BOXWOOD SCALES

No. 1347 : 1947. This British Standard has been prepared in collaboration with the Drawing-Office Material Manufacturers' and Dealers' Association as one of the series of standards relating to drawing-office equipment and materials. Boxwood scales and boxwood scales with celluloid edges, of oval, flat and triangular section, are described and illustrated, the minimum and maximum values of the principal dimensions are listed; materials, workmanship, dividing and figuring are specified, and open divided and fully divided scales are defined and illustrated. Architects', engineers' and surveyors' scales which are considered as standard scales are tabulated in five tables, which include decimal and metric scales. Recommended combinations of scales, or divisions of scales, follow, including draughting machine scales.

Profile Machining*

By N. J. COOKE, A.M.I.P.E.

THE profile machining operations discussed in this paper are confined to turning, with more particular reference to the repetition production of large numbers of small to medium parts on capstan lathes and automatics.

During the war, the author's firm had contracts for very large numbers of turn-buckles for aircraft. The eye or fork ends of the turn-buckles each had a short screw portion either right hand or left hand, and a long unscrewed portion joining the end to the head, this portion being undercut to a diameter slightly below the minimum root diameter of the thread. As the margin of safety on the tensile strength of the material was very low at the specified breaking load, a very close limit on diameter of the undercut portion was called for in order to keep it as strong as possible. For the same reason anything in the nature of an undercut or a circumferential scratch which might provide a weak point was most objectionable.

Because of the slenderness of the job, which, in a typical example, was 1·1in long in the undercut and finished to a diameter of 0·140in ± 0·002in, forming was impracticable even with a steady, as the job deflected away from the form tool, and an impracticably small feed would have been required to avoid the risk of twisting the end off.

The material was a 35/45-ton mild steel, bright drawn from a base material of very low carbon content and very sticky to turn.

The machining method adopted for producing the fork ends is known as "skiving," "randing," or sometimes "shaving," and is fairly frequently used in wood turning, and to a lesser extent in the turning of non-ferrous metals, but not so often in the turning of steel. The principle is the traversing of a tool approximately of the profile desired along a feed line tangential to the elements of the finished profile.

In order to illustrate this as simply as possible, I take as an example the production of the turn-buckle part shown in Fig. 1. In this the tool is shown diagrammatically, both in plan view and end view. It is rigidly secured to the rear slide of a small capstan lathe and cuts by being traversed below the job, reducing the undercut diameter from the thread major diameter previously turned with a roller box in the usual way, and also finishing the taper on the head, this latter being previously roughed down with an ending box.

[The author then dealt to some length with the design and method of making the tool shown in the diagram.]

A cross traverse rate of 0·003in to 0·005in, giving a true feed of about 0·002in to 0·0035in, reducing to zero as the tool crosses the centre, has been found satisfactory for steel and a rate of 0·005in to 0·010in has been found satisfactory for brass. Turning speeds should be about the same as the regular turning speed for the material.

The actual construction of a practical tool holder and the shape of a typical tool block and tool are shown in Fig. 2.

The body carrying the tool holder barrel, to which the tool block is attached, is tongued and bolted to the rear cross slide of a capstan lathe. Provision is made in this block for mounting a parting tool or form tool in addition to the barrel. The barrel is mounted in a plain circular hole passing through the block, in a plane square to the job, inclined at a small angle to the horizontal. A diameter setting is obtained by sliding the barrel in the hole by set screws, thus raising or lowering the tool block as required. Rotation and clamping of the barrel is effected by set screws bearing on flats milled in the barrel. By rotating the barrel with the screws, a level tool edge can be set horizontal. The barrel shank is case hardened and ground to a push fit in the hole.

The head of the barrel is enlarged and has a face machined on it, inclined at the shear angle to the job, and inclined backwards 3 deg. true angle to the vertical. A tongue is machined on the centre of the face with its edges in line with these angles.

The tool blocks consist of blocks of mild steel with high speed steel inserts braze-hardened into them. After brazing the whole block is ground up square and the required profile is ground into the H.S.S. insert, after which the locating slot is milled into the back of the block at the correct dimension from the ground surface, and the hook angle on the cutting surface is also ground. Holes for fixing screws are also provided. Incidentally, a slight lateral clearance is ground on any square shoulders.

The construction has the following advantages:

(1) The tool blocks are easily and rapidly produced, and the calculations necessary are simple.

(2) Setting up time is short, taking very little more than a form tool.

(3) As the tool is bedded straight down on to the slide and pushed down tight by the cutting pressure, the accuracy of the job does not depend on the operator bringing a slide against a stop to a constant pressure.

(4) A blunt tool can be removed in a minute or so, reground on the cutting face on an angle block (kept for the purpose) and replaced within about ten minutes, without any resetting.

(5) Tool life is very long, due to the shearing action. Working on the turn-buckle job as an example, as much as eighty hours has been obtained from a grind.

(6) It is possible to produce many jobs having, say, a collar in the middle, complete in one operation with two close limit ends accurately concentric. This is not by any means easy by a two-operation method turning the job round for the second end, as is usually done.

(7) The use of four-way tool posts on the cross slide can be avoided in many cases.

(8) Both front and rear tool posts can be used on a job independently of the skiving tool, which in itself can easily replace two or three cross-slide stations. Thus, the method is very rapid, as it eliminates several operations in a negligible time, and frequently enables a component requiring several operations to be completed in one.

* Presented to the Institution of Production Engineers, North-Eastern Section, Jan. 20, 1947. Abridged.

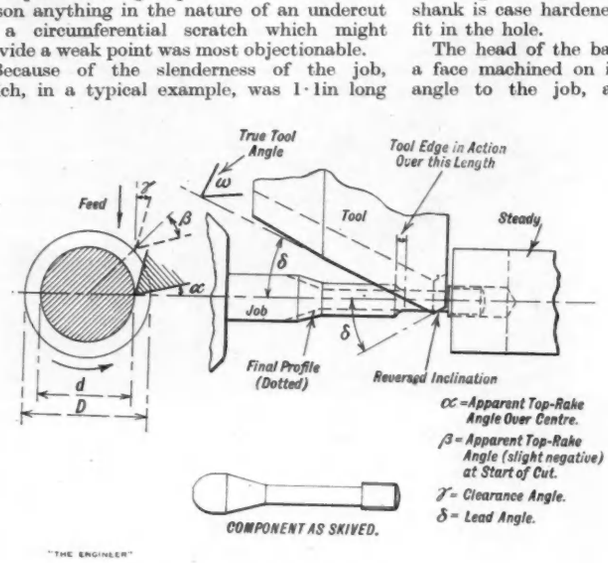


FIG. 1—*Diagram of Turn-Buckle Skiving*

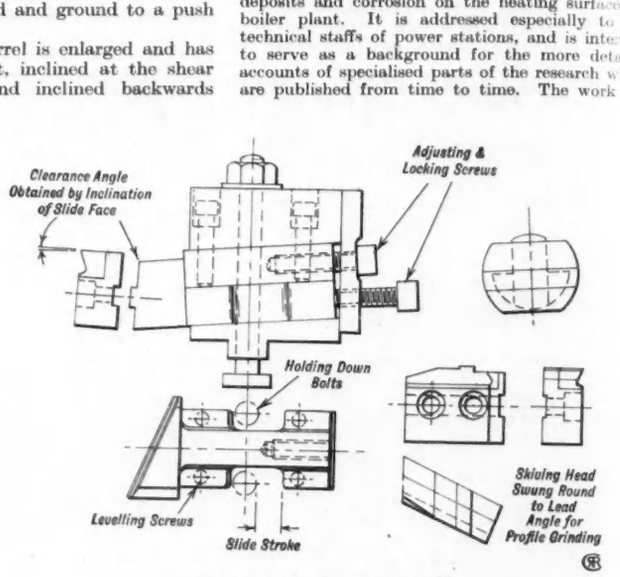

Clearance Angle Obtained by Inclination of Slide Face
Adjusting & Locking Screws
Holding Down Bolts
Skiving Head Swung Round to Lead Angle for Profile Grinding
Levelling Screws
Slide Stroke

FIG. 2—*Construction of Tool Holder*

Technical Reports

Interim Report on External Deposits and Corrosion in Boiler Plant.—Bulletin No. MC/153 of the Boiler Availability Committee, 14, Old Square, Lincoln's Inn, W.C.2.

The *Bulletin* summarises the results so far obtained by the Boiler Availability Committee in its work on the fundamental causes of external deposits and corrosion on the heating surfaces of boiler plant. It is addressed especially to the technical staffs of power stations, and is intended to serve as a background for the more detailed accounts of specialised parts of the research which are published from time to time. The work has been carried out over the last seven years by a number of research organisations, boiler manufacturers and electric power undertakings, in co-operation with the Committee, and is still continuing.

The report is divided into sections describing the nature of external deposits; the mechanism by which deposits may be formed, and the factors affecting deposit formation.

It is suggested that troublesome deposits in the furnaces, superheater and boiler proper, may be classified into three types—birdnesting, bonded, or phosphatic, depending on the properties of the coal burnt, the design of plant and the method of operation.

Birdnesting is the result of very high gas temperatures in the furnace or superheater, and it is therefore recommended that these temperatures should be as low as is economically possible. "Bonded" deposits are held together by a matrix produced essentially from the sodium, potassium and sulphur in the coal, and "phosphatic" deposits are the result of attack of fly-ash particles by phosphorus compounds.

In economisers and air heaters, deposits and corrosion mainly result from the presence in the flue gas of free sulphuric acid, although some economiser deposits are bonded by phosphates.

The fundamental research has indicated that bonded deposits particularly are affected by the presence or absence of certain fine dusts in the gas. Some of these dusts have been added experimentally to power station boilers with encouraging results. It is not certain yet whether combustion processes can be devised which will liberate these beneficial dusts from the firebed and thus eliminate the necessity for adding them separately.

Attention is drawn in the *Bulletin* to features of boiler design which improve availability. The necessity for adequate facilities for "on load" and "off load" cleaning and the importance of tube spacing and accessibility are stressed. With regard to operation, suitably distributed secondary air and short, clean fires are said to have a beneficial effect on availability and on the type and quantity of deposits formed.

Power Production in the Far East

(By our own Correspondent)

THE description of the plans prepared by Dr. John Savage and other American engineers, connected with the 10,500,000-kW hydro-electric plant to be installed in the Yangtze Gorges, which recently appeared in this journal*, has drawn attention to the great possibilities of utilising water power in the Far East. It is not only on the Yangtze River that great volumes of water fall from high mountains to sea level, nor is it in the Yangtze Gorges only that the water flowing in a great river and its tributaries can be utilised for power production. It is probable that no other site on Far Eastern rivers could be found where it would be possible to build such a huge installation as that suggested by Dr. Savage for the Yangtze Gorges. But in the aggregate, many millions of horsepower will, in due course, and at some unknown date in the future, be generated by hydro-electric plants, not only in China, but in other parts of the Far East, where great rivers in places fall rapidly on their journey to the sea.

Early Water Wheels

It is of interest to note that the first record of a water wheel is to be found in ancient Chinese literature. It was installed on a river for lifting water on to rice fields. Wooden water wheels also have been used for centuries in China, for grinding corn or wood into incense powder. They are of the horizontal type, on a vertical shaft and, of course, are very inefficient when compared with modern machines. They use a head of water from four to eight feet.

Local obstruction often delays progress. Some years ago an attempt was made to develop a small hydro-electric plant of about 250 h.p., at Chintze Springs, in the Yellow River area, but the owners of small mills defeated the scheme by demanding exorbitant prices for their holdings and water rights. Yet expert engineers, working under the China Famine Relief Organisation, were convinced that enormous benefits would come to the people in the Yellow River area—a population of 100,000,000—if hydro-electric plants were installed.

Reclamation of Unproductive Land

Amongst other benefits there would be the reclamation of great areas of land, now unproductive. The soil consists of loess, dry, friable material, with particles of very small size. The rainfall in the area is very limited. But hydro-electric power would permit large irrigation schemes to be carried out. The remarkable physical property of loess soil is that when supplied with sufficient water it becomes very productive. Engineers who investigated this problem, about sixteen years ago, came to the conclusion that it would be profitable to install a 50,000 h.p. plant at the Hu-Kou Falls, on the Yellow River, and other smaller installations at other places. The power would be used for pumping for irrigation; that would greatly increase production of food and cotton, as well as for lighting cities, driving mills, and other industrial work.

In Manchuria, now three provinces in North China, the Japanese developed several important hydro-electric schemes. With all their faults, we must give the Japanese credit for their enthusiasm for and practical work connected with hydro-electric power. A greater proportion of the potential water power in Japan was thus utilised than was the case in any other country. In Formosa, as in Manchuria, the Japanese did excellent work in developing water power. Although much of the equipment may now be missing (the Russians are said to have stripped plants in Manchuria) it should be possible to replace it. The civil engineering work, at least, is intact. It is to be hoped that the Chinese will soon re-equip these plants.

* The Engineer, Oct. 4, 1946, pages 294-5.

Three Natural Divisions

The three great natural divisions of China are the basins of the Yellow River, the Yangtze Kiang, and the Si Kiang, or West River; the latter in South China. The two rivers first mentioned are about 2500 miles long, while the Si Kiang is about 1200 miles in length (or half as long again as the Rhine) and is navigable for 1000 miles.

The Yellow River

Two lakes, 13,500ft above sea level, form the source of the Yellow River. Entering the inland province of Kansu, the river passes through a valley which, in the course of 150 miles, drops down from 8000ft to 5200ft, at Lanchow, the capital town of the province. It then turns for 1200 miles along three sides of a quadrilateral to reach the town of Tungkwan, falling from 5200ft to 1000ft. During this journey there are places where the river rushes through rapids; during the last 375 miles to Tungkwan it falls 2000ft. The Hu-Kou Falls are situated 125 miles north of Tungkwan and are capable of developing 50,000 h.p. at the lowest stages of the river, with opportunities for developing another 50,000 h.p. by damming the river near a town 60 miles south of the Falls. Not only can power from the river serve to increase, by pumping, the areas of productive land, it can be used for mills, coal mines in South Shansi, and petroleum distillation and refining in central Shensi, as well as for the fixation of atmospheric nitrogen for fertilisers, nitric acid and pulp products.

The Yangtze River

The giant Yangtze has an annual mean discharge of over one million cusecs and a maximum recorded discharge of over 2½ million cusecs. The gorges are some miles below Chungking, but it is above Chungking (1350 miles from the mouth of the river) that the river falls rapidly. Suifu is 200 miles above Chungking and Batang roughly 1000 miles above Suifu. In that 1000 miles the river falls steadily for 1000ft. It is in these upper reaches, while passing through the rich province of Szechwan (which is about twice the area of the British Isles and with a normal population of 71,000,000, Chungking being the capital) that there are great possibilities for power production. The province is rich in minerals, with an estimated coal reserve of nearly 10,000 million tons, but with an annual production which never exceeded one million tons. If cheap power can be provided, the numerous salt wells, some over 5000ft deep, now worked by muscular energy of animals and men, would absorb a considerable amount. As natural gas is available in the region of the wells, it is probable that gas engines will be used for the purpose.

Thermal Power

Until the Japanese invasion the large industrial centres in China were on the East coast, Shanghai being the most important. Although there were several other power supplies in Shanghai the Riverside station, with a maximum output at any one moment of about 200,000 h.p., and with the highest load factor of any heat engine power station on record, was the most important. The municipal council of the Shanghai International Settlement sold the power station and the supply system to an Anglo-American syndicate for £10,000,000, a few years before the Japanese invasion of China.

The total coal production in China (including Manchuria), before the Japanese invasion, was not more than 28 million tons per annum, of which the Fushun mines in Manchuria (Japanese management) and the Kailan mines in North China (British management) produced each rather more than a quarter of the total annual output of the country. Production per day per miner was, in tons, 1·90, at Fushun, and 0·85 at Kailan. If we include the 202,000 small native mines, as well as the eight larger mining centres, where a minimum of 2200 men and a maximum of 52,000 men (at Fushun) were employed, the daily production per man was estimated at 0·35 tons. Incidentally, it is of interest to note that Chinese were using coal centuries before it was used in Europe.

Demand for Mechanisation

The outstanding feature of the announcements made by Chinese officials, leading business men, and intellectuals, is the demand for mechanisation, which, of course, means power production. The old prejudices against the use of machinery have disappeared, but the invasion by Japan has introduced the complications of an inflated currency. Although the newspapers in Britain devote considerable space to the political tension in China, there are vast areas of the country unaffected by the so-called communists. While it is obvious that the huge scheme called the Yangtze River Dam Project must be controlled by the Chinese Central Government, it is not stated how it will be financed. On the other hand, there is no national more industrious than the average Chinese; none more eager to make money.

It would seem that power production in China will be developed by three agencies, *viz.*: (1) the Central Government; (2) by Provincial Governments, now 21 in number, and (3) by private enterprise. Recent reports from Shanghai are encouraging; a prominent Chinese engineer, at little while ago, informed the writer that inflation of the currency would not hinder the import of machinery.

Typical of the enterprise of the Chinese is the rehabilitation of the power plant supplying the famous Wing On textile mills in Shanghai. In the Woo-Sung plant a 1000-kW set was placed in commission in August, last, in spite of the great amount of repairs and replacements needed. In November, an additional 3600-kW set was at work, but 1500 kW had to be supplied from it for public consumption, as there is a great shortage of power in Shanghai. Conditions in Shanghai are gradually improving; it is the most important port in China, and the Communists have openly stated that they do not intend to take action in that city. Although there may be delay in commencing work on the Yangtze Gorge scheme, which will take years to complete, there can be no doubt of the desire of Chinese industrialists to increase power production in the country.

During the last hundred years the British took a leading part in the development of foreign trade in China; they were the pioneers of mechanisation in that country. They obtained a reputation for fair dealing and were trusted by the Chinese to a greater degree than any other nationals. British politicians are constantly emphasising the importance of increasing this country's exports. There have always been difficulties to overcome in connection with trade in China, but the British persevered and some of them made fortunes. The great demand in the future will be for engineering imports.

Power production is the basis of mechanised industry and Chinese engineers and industrialists realise that fact. That is why the plans for a 10,500,000-kW plant for the Yangtze Gorges are of great interest to engineers. It is proof that the Chinese are thinking of power production on a big scale. On the other hand, there are a large number of factories and cities for which comparatively small plants will be needed. Even before the war there were several independent plants in Shanghai, as at the Wing On Textile Mills, in spite of the low charges made by the Shanghai Power Company. It is probable that the immediate demand will be for comparatively small power plants.

Industrial and Labour Notes

Unemployment

The latest unemployment figures issued by the Ministry of Labour relate to March 10th, on which date there were 761,257 insured persons registered as being out of work. This total includes 314,653 who were temporarily stopped, but does not take into account 24,000 people who were stood off on March 10th, but who had not claimed unemployment benefit.

On March 5th there were 789,854 insured persons registered as unemployed, and on February 22nd—when unemployment owing to the fuel crisis was at its peak—the comparable figure was 1,870,323. In the regions which cover the area where the use of electrical power by industry was restricted, the total drop in unemployment between February 22nd and March 10th—including those not claiming benefit—is estimated at 1,560,000, or 73 per cent of the number unemployed at February 22nd.

Production Targets

Mr. George Dickson, acting Chairman of the London and South-Eastern Regional Board for Industry, has recently circulated to employers, management staffs, trade unionists and other workpeople in the region a pamphlet urging that production targets should be properly planned and full employment ceilings should be agreed upon. To employers, the suggestion is made that efficient production targets should be set for industries and individual firms with the assistance of trade associations or the regional boards for industry; but, the pamphlet adds, "no one can take away your responsibility for the efficient management of the resources at your disposal." Employers are also exhorted to make sure that their workpeople know what they are trying to do.

To trades unionists, Mr. Dickson says, in the pamphlet, "Keep democratically in touch with your union for general guidance, and see that there is an efficient production target planned for your factory. Make sure you understand it and are doing all you can to help the management to get more efficient output from the raw materials and machinery now available. Democratic full employment is not an assured inheritance, and cannot be guaranteed by any Government; we have still to win it by our efforts in Great Britain."

Coal for Industry

In our last issue we recorded Sir Stafford Cripps' statement that the Government hoped to improve the coal allocation to industry. At the end of last week the Board of Trade announced that as from Monday last, April 14th, the basic coal allocation to industry throughout the country would be increased from 33⅓ per cent to 50 per cent. It was also announced that Regional Fuel Allocation Committees would continue to supplement the basic coal allocations of firms engaged on work of particular importance from the pools made available for the purpose.

The new arrangement will operate until May 31st, and by it industry should receive the coal which was to be made available under the realistic plan devised by the President of the Board of Trade in January, a plan which could not be implemented on account of the electricity crisis.

The Minister of Fuel and Power, Mr. Shinwell, spoke during last week-end about coal output, saying that if 220,000,000 tons of coal could be produced in the next coal year beginning on May 1st, it would perhaps be possible to satisfy the needs of industry, increase household supplies and have some surplus for a revival of coal exports. The figure of 200,000,000 tons was set by the Government as a target because there were certain unknown factors, particularly the five-day week. If the present rate of recruitment to the mines was maintained, however, if mine workers were given the proper encouragement and no hitches occurred in the production of mining equipment, it should be possible, Mr. Shinwell asserted, to produce all the coal the country needed.

Professional Manpower

The Minister of Labour has decided that the prospects of employment in all professions and occupations of similar status, including those in the technical and scientific field, should be reviewed, and consultations on the matter have already taken place with Government Departments and professional bodies.

Specially appointed sub-committees of the Technical Personnel Committee—of which Lord Hankey is chairman—are to make a number of inquiries into the manpower demand and supply position in scientific and technological fields over the next five to ten years. Influential panels have already been formed to cover the main branches of the engineering profession and the architectural, surveying, valuation and allied professions. It is hoped also to conduct inquiries into the demand for and supply of physicists, mathematicians and metallurgists at an early date.

Psychology and Production

In his Presidential Address to the National Institute of Industrial Psychology last week, Lord Piercy made reference to the problem of production which was agitating this country, and to the associated problems of incentives and effieiency. The organisation of modern production, Lord Piercy said, fell under three main heads, which were the application of science and technical skill to a material product, the systematisation of operations, and the organisation of sustained co-operation. If efficient work and optimum output were wanted, then it was necessary to find, as nearly as possible, for each person the work he could do easily and well, and also provide him with working conditions and environment which would enable him to do it with the least possible wear and tear.

That was a matter, Lord Piercy continued, which linked up with the problem of incentives. Personnel selection, skilled ordering of the layout, movement study and a rational working day all helped towards efficient production, but there was still a tremendous contribution under these heads to be made in British industry. The attitude and performance of one person, however, could not be considered without taking into account the mutual relations and attitudes of the group. For where individuals became a team, not only did their productivity increase, but their personal outlook and their ability to collaborate changed for the better.

One of our most pressing current problems, Lord Piercy thought, was to get throughout industry more manifestation of common purpose. That manifestation was to be found in some industries, but by no means in all, because, as principles of organisation, we did not use—mostly because we did not know—the truths being thrown up by the new developments of the studies in which the National Institute of Industrial Psychology was interested.

Port Delays

The report of the Liverpool Steam Ship Owners' Association, which was presented at the annual meeting on Tuesday last, says that a recent inquiry into the delays to ships in port revealed that in 1946 the turn-round of ships in Liverpool was taking at least one-third as long again as in the immediate pre-war period. Failure to give a full and fair day's work, the report comments, is apparent both at the docks and in the ship repair yards, notwithstanding that an essential element in the restoration of our overseas trade is the quick turn-round of ships.

Until the difficulties in this matter are overcome, the report asserts, shipping companies cannot give their customers the service to which they have been accustomed and which they must have if trade is to prosper. Normally, the necessary adjustments would be made by the ordinary processes of collective bargaining, in which the employers would be responsible for seeing that the country got satisfactory service at a reasonable cost, but a growing tendency of the Government to intervene in the bargaining is making it difficult for employers to carry out their functions.

The report goes on to say that as Government intervention relieves both employers and trades unions of their responsibility for a satisfactory settlement, it is unlikely to make the task easier, and, in the event of failure, it will be impossible to fasten the blame on anyone. In the Association's opinion, it would be better if the whole responsibility of failure to produce results satisfactory to themselves and the community was placed upon the employers and the trades unions.

Iron and Steel Production

Figures relating to the production of iron and steel in the United Kingdom in the month of March have now been published and show that output was seriously curtailed by the continued limitation of fuel supplies. Production of pig iron averaged 123,100 tons a week, which represents an annual rate of 6,400,000 tons, and the output of steel ingots and castings averaged 196,000 tons a week, or an annual rate of 10,190,000 tons. These figures are the lowest recorded this year.

In the first quarter of 1947 pig iron production averaged 134,400 tons a week, or an annual rate of 7,114,000 tons, and the average weekly output of steel was 216,000 tons, or an annual rate of 11,232,000 tons. In the comparable quarter of 1946 the annual production rate of pig iron was 7,566,000 tons and of steel 12,617,000 tons.

The Tin Study Group

The first meeting of the Tin Study Group opened in Brussels on Tuesday last, April 15th, and concludes to-day. This group has emerged from the resolutions passed at the International Tin Conference in London last October, which was attended by delegations from the eight most important tin-producing and consuming countries.

Invitations to attend the meeting of the Study Group were issued by the Belgian Government to all nations interested in tin and willing to co-operate in the work of the Group, the purpose of which is to survey the long-term tin supply and demand position. The United Kingdom delegation was headed by Mr. W. Archer, of the Ministry of Supply, who was accompanied by advisers representing smelting and consuming interests.

An Austrian Industrial Mission

An industrial mission from Austria arrived in this country at the beginning of the week and is carrying out a programme of visits which has been arranged by the Board of Trade in co-operation with the Federation of British Industries, the British Engineers' Association, the London Chamber of Commerce and other organisations.

The purpose of the mission is to enable Austrian industrialists to investigate the possibilities of Anglo-Austrian trade and the purchase of foreign products and the sale of Austrian goods to third markets through the United Kingdom. The mission is led by Dr. Wilhelm Taucher, of the University of Graz, who, on arrival, referred, amongst other matters, to the long-term plans for the agricultural development of the eastern portion of Austria, to the development of power from soft coal, and to the oil in the country which it is intended to exploit.

French Engineering News

(From our French Correspondent)

PARIS, April 11th

The first large merchant ship constructed by the French since the Liberation was recently launched at Brest. She is the "Penlan," named after the first merchant ship sunk by the Germans, and has a deadweight capacity of 4700 tons. She has four holds served by eight 5-ton winches. The vessel is 113·6 m long, 14·78 m wide, and 7·4 m in depth. Propulsion is by a reciprocating steam engine and exhaust turbine, supplied with steam by two cylindrical boilers of the Prudhon-Capus type. The designed speed is 12 knots, with an output of 2000 s.h.p.

* * *

The Renault nationalised plant is preparing machinery for the large-scale production of the Renault 4 h.p. car. Tooling-up will be completed by the end of the year. It is likely that the preliminary work could be speeded up, but this is considered unnecessary since production on a large scale pre-supposes a large consumption of raw materials and power, and the present allocations cannot be increased this year. Present production comprises 100 light 6 h.p. cars a day, of which five-sixths leave France. Production of heavy and light lorries varies between 120 and 130 a day, of which four-fifths remain in France.

* * *

Tribute is paid to British co-operation in the restoration of the Channel ports, particularly Le Havre. Vickers-Armstrongs, Ltd., was given the task of constructing and installing two floating caissons and a dry dock for the port, the larger of the caissons being claimed to be second in point of size only to the entrance caisson to the great basin of Sydney. It was constructed entirely of welded steel, and its dimensions are: length, 40·25 m; width, 8·25 m., and height, 18 m. Its displacement is 2766 tons. The caisson was deliberately inverted when launched, after which a delicate operation was necessary to right it. This was achieved by adding the permanent ballast before launching and by regulating the water ballast in the watertight compartments of the caisson. Towing the caisson to Le Havre is being done by William Watkins, Ltd., of Liverpool, and two powerful tugs are being used for the purpose. At Le Havre the caisson will have to be manœuvred between two grounded vessels before being moored. It will be placed across the mouth of the basin and sunk by filling the ballast compartments. At first it will be kept in position by hawsers, but when the water has been pumped from the dry dock itself, the caisson will be kept in place by water pressure in the tidal basin.

* * *

Electrification of rural areas is to be pushed ahead in France during the next decade. It is hoped that increased electrification will make rural life more attractive and stop the exodus to towns. The complete programme will not electrify all isolated farms, as this would involve expense out of proportion to benefits received. Nevertheless, the rural population will, on the whole, receive power and light sufficient to improve their standard of living, and some 15,000 farms will be able to install machinery. By 1950 rural consumption is expected to reach 2·2 milliard kWh, or 480 kWh per consumer, and this figure is expected to increase as the use of electric domestic apparatus grows.

* * *

Generation of hydraulic power in France over the past few years has varied between 8 and 12 milliard kWh, total power having increased from 2,250,000 kVA in 1930 to 4,250,000 kVA in 1945. Since France has not the coal to increase thermal production, every effort is to be made to increase hydraulic power to 7,800,000 kVA. By 1951 production should reach 35 milliard kWh, compared with the present 20 milliards. The plan envisages installations of 220,000 kW at Chastang and 180,000 kW at Bort. At Ottmarsheim, a new plant will utilise the Rhine waters over a fall of 16 m. The 1100 cubic metre flow will permit power installations of 200,000 kW.

Notes and Memoranda

Rail and Road

AMERICAN LOCOMOTIVE BUILDING.—The annual report of the American Locomotive Company shows that unfulfilled orders on the books at March 7th totalled about 80,000,000 dollars. Uncompleted orders for oil-electric locomotives comprised 75 per cent of the work in hand, and export orders—chiefly for steam locomotives—accounted for less than 10 per cent. The report expresses the view that short-term prospects are that the company may expect a fair amount of overseas business in steam locomotives as world trading conditions and international banking facilities improve.

SNOWDRIFTS ON THE C.P.R.—Snowstorms, said to be the worst in the history of Western Canada, which raged for three weeks during late January and the early part of February, blocked 3000 miles of Canadian Pacific Railway track, and at some points produced drifts up to telegraph-pole height. *Railway Age* says despite conditions never before encountered on the C.P.R.—which for the first time in history blocked its main line between Moose Jaw, Sask., and Regina—the tracks were completely cleared one week after the storms ceased. Snow ploughs and bulldozers were employed twenty-four hours daily against the 20ft drifts, packed hard by the force of high winds.

NEW WOODHEAD TUNNEL, L.N.E.R.—The London and North-Eastern Railway Company has applied for parliamentary powers to build a new double-line tunnel at Woodhead on the main line between Sheffield and Manchester. The existing twin tunnels under the Pennine Range at this point are just over 3 miles in length, the fourth longest in Great Britain. The Sheffield-Manchester line carries a very heavy general freight traffic, in addition to passenger services between Manchester, Sheffield, the Midlands and South and the East Coast. The first tunnel, which accommodated a single line only, was started in 1838 and opened in 1845. The second tunnel was started in 1847 and completed in 1852. During the war years the Woodhead tunnels carried a tremendous volume of traffic, and the amount of maintenance work had to be reduced in order to avoid interruption to the trains carrying war supplies of all kinds. As soon as possible after the end of the war urgent repair work had to be undertaken, and various sections of the tunnels have been relined in recent months. This has necessitated the closing first of one tunnel and then of the other, all traffic being worked through the remaining tunnel, which has seriously reduced the carrying capacity of the line, as many trains have had to be diverted. Although these emergency measures will restore the tunnels to a satisfactory condition for the time being, the company has been advised by experts that a great deal of work will have to be done to put the tunnels into perfect condition, and this will not only be very costly, but will necessitate the complete closing of each tunnel in turn for long periods. In the circumstances the directors of the L.N.E.R. have reached the conclusion that the only satisfactory course is to drive an entirely new double-line tunnel, parallel with the existing tunnels.

Air and Water

RADIO AIDS FOR CIVIL AVIATION.—Just before the Easter adjournment, Lord Nathan, Minister of Civil Aviation, stated in the House of Lords that he proposed to set up a scientific committee on radio aids for civil aviation. Sir Robert Watson Watt would act as consultant, the Minister said, and the radio industry had offered to assist in the establishment of long-term plans. Lord Nathan also said that the Ministry of Supply had placed a development contract for six airborne radar sets to give warning to aircraft of dangerous ground and dangerous turbulent cloud. From them it was hoped to develop a device which would give warning of potential collision with other aircraft.

DISPOSAL OF GOVERNMENT-OWNED SHIPS.—As a result of the Ministry of Transport's third invitation to tender for Government-owned ships (ex German vessels), forty-nine of the total of fifty-nine originally offered have been disposed of by sale or charter. One ship was withdrawn after the invitation was issued on November 26, 1946, and no acceptable offers were received in respect of the other nine vessels. The ships were offered in two groups. Those in the first were subject to minimum prices for purchase and/or monthly minimum rates for charter. Those in the second group were for sale only, as they lay, with no minimum price stated. The total amount realised by the sales was £3,526,850.

Miscellanea

CORRUGATED IRON SHEETS.—The Minister of Supply intimated, in a written Parliamentary reply last week, that his department had restricted all overseas sales of corrugated iron sheets in order to maintain supplies for essential home needs.

THE MAY LECTURE.—The thirty-seventh May Lecture of the Institute of Metals will be delivered by Sir Wallace Akers on Wednesday, May 21st, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1. The subject of the lecture is "Metallurgical Problems Involved in the Generation of Useful Power from Atomic Energy."

THE HATFIELD MEMORIAL LECTURE.—The second Hatfield Memorial Lecture, arranged jointly by the University of Sheffield and the Iron and Steel Institute, will be delivered by Dr. C. Sykes, F.R.S., on Wednesday, May 14th, at 8.30 p.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1. The subject of the lecture is "Steels for Use at Elevated Temperatures."

LEAD PRODUCTION IN U.S.A.—Preliminary estimates of the mine production of lead in the U.S.A. and Alaska during 1946 indicate an output of 332,478 tons of recoverable metal, a decrease of 15 per cent compared with 1945. It is estimated that 355,600 tons of refined lead and 51,100 tons of antimonial lead were produced at primary refineries in 1946. Prolonged strikes at the mines, smelters and refineries were, it is stated, the chief reason for the declining output, although labour shortage during last year prevented capacity operations at many producing plants.

MICROSCOPIC EXAMINATION OF WOOD.—The Forest Products Research Laboratory, Princes Risborough, Bucks, has issued a small pamphlet dealing with the preparation of wood for microscopic examination. It described various techniques which have proved successful and which are based on several years' experience at the Laboratory. In addition to setting out the procedure for the routine preparation of sections of solid wood, the pamphlet gives directions for dealing with plywood, veneers and charcoals.

MOSCOW'S NATURAL GAS PIPE LINE.—The assembly of the six compressor stations of the Saratov-Moscow natural gas pipe line was completed a few months ago, according to *Foreign Commerce Weekly*. The pipe line is 850 kiloms. in length and crosses more than 100 rivers, lakes and marshes. In a recent four-month period Moscow is reported to have received 40,000,000 cubic metres of natural gas, and the average daily consumption is increasing. With the new compressor stations it is expected that the amount of natural gas reaching Moscow daily will be about 1,350,000 cubic metres.

NICKEL IN 1946.—Reviewing the activities of the International Nickel Company of Canada, Ltd., in 1946, the chairman, Mr. Robert C. Stanley, said recently that deliveries of nickel were curtailed in the early part of last year by strikes in the major nickel-consuming plants, but later on the demand increased. During the first six months of 1946 mining and smelting operations were about 50 per cent of the company's capacity, but by the end of the year the rate of production was approximately 75 per cent of the maximum wartime figure. Ore actually mined in 1946 was 7,736,334 short tons, compared with an average annual tonnage of 11,453,154 for the three preceding years. Proven ore reserves at the end of the year were 217,142,000 short tons, containing 6,861,000 tons of nickel-copper.

INSTITUTION OF CHEMICAL ENGINEERS.—The twenty-fifth annual corporate meeting of the Institution of Chemical Engineers was held at the Connaught Rooms, London, W.C.2, on Thursday, April 10th, with Mr. Hugh Griffiths, the retiring President, in the chair. After the routine business and the presentation of medals, Mr. Griffiths delivered his Presidential Address, the subject of which was "Crystallisation." Later, the Institution luncheon took place and was well attended by members and their guests. The toast of "The Guests" was proposed by Mr. Griffiths and was acknowledged by Mr. Geoffrey Heyworth, Chairman of the Advisory Committee of the Department of Scientific and Industrial Research, who spoke appreciatively of the Institution's work in the field of education and training. At the conclusion of the luncheon, the retiring President introduced his successor, Mr. H. W. Cremer, and invested him with the presidential chain of office.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

British Industries Fair

Monday, May 5th, to Friday, May 16th.—London, Olympia and Earls Court; Birmingham, Engineering and Hardware Section, Castle Bromwich, Birmingham.

Chemical Society

Thursday, May 1st—Burlington House, Piccadilly, W.1. "Nitration of Olefines," C. W. Scaife; "Reactions of the Nitroparaffins," A. Lambert; "Addition Reactions of Nitro Olefines," R. L. Heath; "Formation and Reduction of Two and Three-Nitro Alkyl Cyanides," G. D. Buckley. 7.30 p.m.

Illuminating Engineering Society

To-day, April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "Portable Photometers," J. S. Preston. 6 p.m.

Friday, May 9th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "The Physical Nature of Light," J. Cull. 6 p.m.

Tuesday, May 13th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. Annual general meeting. 6 p.m.

Institution of Civil Engineers

Friday, April 25th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield. "Soil Mechanics," N. S. Boulton. 7 p.m.

Wednesday, April 30th.—N. WESTERN ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester. Annual Dinner. 6.30 p.m.

Institution of Electrical Engineers

Tuesday, April 22nd.—SCOTTISH CENTRE: The Royal Technical College, George Street, Glasgow. "The Grid System in Wartime," J. Hacking and J. D. Peattie. 6.15 p.m.

Wednesday, April 23rd.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "New Possibilities in Speech Transmission," D. Gabor. 5.30 p.m.

Friday, May 2nd.—N.-EASTERN STUDENTS' SECTION: County Hotel, Newcastle-on-Tyne. Annual general meeting and annual dinner. 6.45 p.m.

Institution of Heating and Ventilating Engineers

Wednesday, April 30th.—LIVERPOOL BRANCH: Accountants' Hall, Fenwick Street, Liverpool. "Feed Water Treatment," R. Williams. 6.30 p.m.

Tuesday, May 6th.—LONDON ASSOCIATE MEMBERS AND GRADUATES' SECTION: Junior Institution of Engineers, 39, Victoria Street, S.W.1. "Hot Water Supply by Electricity," J. I. Bernard. 6 p.m.

Institution of Mechanical Engineers

Friday, April 25th.—Storey's Gate, St. James's Park, S.W.1. "Stress Concentration and Fatigue Failures," Professor S. Timoshenko. 5.30 p.m.

Saturday, April 26th.—N. WESTERN GRADUATES: Engineers' Club, Albert Square, Manchester. "Electronics for the Mechanical Engineer," K. M. Fantom. 2.30 p.m.

Institution of Post Office Electrical Engineers

Monday, April 28th.—Faraday Building (South Block), Knightrider Street, E.C.4. "Repeater Station Power Supplies," K. W. Hix. 5 p.m.

Institution of Production Engineers

Monday, April 21st.—HALIFAX SECTION: White Swan Hotel, Halifax. "Engineering Applications of Polarised Light," J. Ward. 7 p.m.

Thursday, April 24th.—Inst. of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Managerial Problems," Mr. Griffin. 6.30 p.m.

Friday, April 25th.—LINCOLN SUB-SECTION: Lincoln Technical College, Lincoln. "X-Rays in Industry," J. L. Mullins. 6.30 p.m.

Thursday, May 1st.—NOTTINGHAM SECTION: Victoria Station Hotel, Nottingham. Annual general meeting. 7 p.m.

Thursday, May 8th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "A Practical Approach of Research to Industry," H. W. Hobbs. 6.30 p.m.

Institution of Structural Engineers

Thursday, May 22nd.—11, Upper Belgrave Street, S.W.1. Annual general meeting. 6 p.m.

Junior Institution of Engineers

To-day, April 18th.—39, Victoria Street, S.W.1. "Some Notes on Ropes," R. P. Mears. 6.30 p.m.

Monday, April 21st.—SHEFFIELD SECTION: Metallurgical Club, West Street, Sheffield. "Steam Locomotives for Express Traffic on the Railways of Great Britain, 1906–46," C. B. Harley. 7 p.m.

Friday, April 25th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Annual Dinner. 6.45 p.m.

Friday, May 2nd.—39, Victoria Street, S.W.1. "The Post Mill," Rex Wailes. 6.30 p.m.

Friday, May 9th.—Institution of Civil Engineers, Great George Street, S.W.1. "The Synthesis of Oil from Coal by the Fischer-Tropsche Process," C. C. Hall. 6.30 p.m.

London Association of Engineers

Saturday, May 3rd.—Charing Cross Hotel, W.C.2. "Precision Measuring Instruments," C. O. Tayleron. 6.30 p.m.

Manchester Statistical Society

Friday, April 25th.—INDUSTRIAL GROUP: Society of Architects, 16, St. Mary's Parsonage, Deansgate, Manchester. "Probability and the Experimenter," E. D. van Rest. 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, April 18th.—Mining Institute, Newcastle-on-Tyne. "Experiments in the Lithgow Propeller Tunnel," A. Emerson and L. W. Berry. 6 p.m.

Wednesday, April 23rd.—STUDENTS SECTION: Bolbec Hall, Newcastle-upon-Tyne. "Ships' Deck Machinery," W. F. Rogerson. 6.45 p.m.

Monday, April 28th.—Mining Institute, Newcastle-upon-Tyne. "Some Model and Full Scale Experiments on Side Launching," F. H. Todd and E. Laws. 6 p.m.

Royal Aeronautical Society

Thursday, April 24th.—Inst. of Civil Engineers, Great George Street, S.W.1. "The Risk of Fire and Fire Prevention Methods," J. W. Drinkwater and W. G. Glendening. 6 p.m.

Royal Statistical Society

Monday, April 21st.—SHEFFIELD GROUP (INDUSTRIAL APPLICATIONS SECTION): Royal Victoria Station Hotel, Sheffield. "The Application of Statistical Techniques to Research and Testing," M. Milbourn. 6.30 p.m.

Sheffield Metallurgical Association

Tuesday, April 29th.—198, West Street, Sheffield. "Springs for High Duty Purposes," Brinley Jones. 6.30 p.m.

Tuesday, May 6th.—198, West Street, Sheffield, 1. "Heat-Resisting Steels," D. A. Oliver. 6.30 p.m.

Society of Chemical Industry

Thursday, May 15th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Sawdust Cement and Other Sawdust Building Products," Dr. T. W. Parker. 6 p.m.

Stephenson Locomotive Society

Saturday, April 19th.—N. EASTERN BRANCH: Central Methodist Church Hall, Newcastle-on-Tyne. "The Churchward Locomotives of the G.W.R.," W. A. Tuplin. 2.30 p.m.

Women's Engineering Society

Thursday, May 8th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester. "Capacitors: Their Manufacture and Testing," Miss W. Hackett. 6.30 p.m.

Launches and Trial Trips

BRITISH ISLES, motor tanker; built by Furness Shipbuilding Company, Ltd., for the British Tanker Company, Ltd.; length 490ft 10in, breadth 61ft 9in, depth 33ft 11in; 12,250 tons deadweight. Engines, single-screw, four-cylinder, Doxford opposed-piston, reversible oil, with cylinders 600 mm, bore by 2320 mm stroke, developing 3100 b.h.p. Launch, March 24th.

Reports on German Industry

Limited numbers of copies of the reports of Intelligence Objectives Sub-Committees on German Industry listed below can be obtained from H.M. Stationery Office at the prices stated.

No. of report.	Title.	Post free. s.	d.
B.I.O.S.:			
626	Drying, Briquetting and Low-Temperature Carbonisation of Brown Coal in Lurgi-Spuelgas Retorts	2	1
683	Hydrogen Peroxide: Production by Electrolysis of 35 per cent Solutions: Deutsche Gold and Silver Anstalt	2	8
698	Survey of the German Heavy Textile Proofing Industry... ...	2	1
708	German Alkaline Accumulator Industry	1	7
713	Notes on Items of Chemical Plant at Works of I.G. Farbenindustrie, Knapsack, Dr. Alexander Wacker, Burghausen, Anorgana, Gendorf, I.G. Farbenindustrie, Hoechst	1	7
715	The Microanalytical Methods Employed in the Analytical Laboratories of I.G. Farben, Elberfeld-Wuppertal, Germany	1	1

During the past few months amendments and addenda to the following reports have been issued and made available at H.M. Stationery Office sales offices:—C.I.O.S. Nos. XXVIII–18, XXXIII–23; B.I.O.S. Nos. 35, 135, 199, 217, 307, 340, 345, 363, 405, 422, 423, 429, 438, 450, 468, 507, 572, 591, 773; F.I.A.T. No. 273.

An almost complete set of German patent specifications, accepted by the Berlin Patent Office during the war, has been secured for the United Kingdom. The specifications, for which either annual or weekly subject-matter and name indices are available, can be seen by the public at the Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.2. Both the indices and the specifications are in German. Photographic copies of any specification and drawings may be obtained at the rate of 6d. per page.

Personal and Business

MR. J. M. THORNLEY has been appointed representative in Scotland of E. Boydell and Co., Ltd.

MAJOR-GENERAL R. K. ROSS, C.B., has been appointed Director of the British Road Federation.

DE LA RUE PLASTICS, Ltd., states that its name has been changed to British Moulded Plastics, Ltd

MR. B. HAROLD RUSSELL has been elected a Director of the Cunard Steam Ship Company, Ltd.

MR. W. A. JENKINS and Mr. E. P. Jenkins have been appointed directors of Robert Jenkins and Co., Ltd.

MR. R. COX has been appointed sales director of the Yorkshire Switchgear and Engineering Company, Ltd.

MR. R. MARSHALL ROBSON has been appointed an additional director of Vaughan Brothers (Drop-Forgings), Ltd.

MR. L. R. RICHARDS has been appointed branch manager of the Belfast plant office of Crompton Parkinson, Ltd.

MR. THOMAS ADIE has been appointed chief electrical surveyor to the Norwich Union Fire Insurance Society.

POOLEY AND AUSTIN, Ltd., announces that its London address is now 77, Great Peter Street, Westminster, S.W.1.

MR. F. C. LOUGHBOROUGH has been appointed sales manager, equipment division (commercial), of the Plessey Company, Ltd.

MR. H. V. POTTER, managing director of Bakelite, Ltd., has been elected to the grand council of the Federation of British Industries.

MR. C. F. HUEBNER has been appointed controller of purchases to the British Oxygen Company, Ltd., at Grosvenor House, Park Lane, W.1.

MR. W. L. HALL has been appointed chief officer of the liaison department of the British Non-Ferrous Metals Research Association.

MR. J. P. REYNOLDS has been appointed chairman of the Scottish Machine Tool Corporation, Ltd., in succession to the late Sir Harry Green.

CYC-ARC, Ltd., is the name of a new company which is taking over the business of Stelmar, Ltd., makers of Cyc-Arc stud welding equipment.

FERODO, Ltd., has opened a new South London depot at 35, Clapham High Street, S.W.4 (telephone, Macaulay 3381; telegrams, "Frodofix, Phone").

MR. P. S. WAKEFIELD, consulting engineer on turbines to the Brush Electrical Engineering Company, Ltd., has retired after twenty-three years' service with the company.

SIR WILLIAM HALCROW AND PARTNERS have taken Mr. Peter A. Scott, M. Inst. C.E., Mr. C. M Roberts, M. Inst. C.E., and Mr. J. A. Johnston, M. Inst. C.E., into partnership.

RICHARD CRITTALL AND CO., LTD., announces the formation in the U.S.A. of a subsidiary, to be known as Richard Crittall Radiant Heating Inc., 665, Fifth Avenue, New York.

MR. A. J. PHILPOT, director of the British Scientific Instrument Research Association, has been appointed Director of the Scientific Manufacturers' Association of Great Britain, Ltd.

EDGAR ALLEN AND CO., LTD., announces the retirement of Mr. Cecil Myers, senior representative in the Lancashire and N.W. England areas, after forty-five years' service with the company.

THE INDUSTRIAL DIAMOND INFORMATION BUREAU has been taken over by the Diamond Research Department of Industrial Distributors (1946), Ltd. It will continue to operate from 32–34, Holborn Viaduct, E.C.1.

THE MINISTER OF SUPPLY has appointed Engineer Vice-Admiral Sir Harold Brown as Chairman of the Machine Tool Advisory Council in succession to Mr. S. F. Steward, who has resigned in order to give full time to his business interests.

Contracts

FREDERICK PARKER, LTD., has been selected as one of a group of British firms to supply machinery to the value of approximately £400,000 for constructing a hydro-electric scheme at Castelo do Bode, Portugal. The scheme entails building a dam through the Zezere River, a tributary of the Tagus. The plant to be supplied by Frederick Parker, Ltd., consists of three complete gravel-handling plants for conveying, washing, screening, and storing 300 tons of gravel per hour.

A Seven-Day Journal

Bankside Power Station

In the House of Commons, on Tuesday evening, April 22nd, Mr. Lewis Silkin, the Minister of Town and Country Planning, announced that the Government had given conditional approval to the proposal of the City of London Electric Lighting Company to build a new 210,000-kW power station on the site of the existing power station at Bankside. It was, however, provided that electricity must be generated by oil, and that the power station building must be set back from the River Thames in order to allow the proposed road and promenade along the south bank of the river. The Royal Fine Art Commission would be consulted on the design of the building, which, Mr. Silkin said, would be undertaken by a very eminent architect. Despite the very urgent need for additional generating facilities, the Government, before agreeing to the site, had given, he said, long and careful thought to the effect of the proposed building, not only on St. Paul's Cathedral, but on the proposals in the County of London Plan for the redevelopment of the south bank. The Government was satisfied that with the safeguards proposed the future of the south bank would not be prejudiced by the power station, nor, having regard to the distance across the river, could the Ministry accept the view that the historic dominance of St. Paul's would be threatened. There was a good discussion in the House and several speakers opposed the idea of constructing a large power station on this particular site. The London County Council had offered an alternative site at Rotherhithe, but it was rejected, Mr. Silkin said, because it would take at least two winters longer than the Bankside site before electricity could be provided. Mr. Silkin promised to consider a suggestion made by Mr. Eden that a model of the proposed station should be made and exhibited in the House, so that members could judge for themselves as to the suitability of the site. In that matter, Mr. Eden said, we were dealing with the future of the finest monument in the City of London. Mr. Skeffington-Lodge gave notice that, in view of the unsatisfactory nature of the reply, he would raise the matter on the adjournment.

B.E.A.M.A. Report

The thirty-sixth annual general meeting of the B.E.A.M.A. took place on Thursday, April 17th, at the Connaught Rooms, London. Mr. E. C. Holroyde, Chairman of the Council, presided, and the report was adopted. Mr. Holroyde referred to the retirement of the Director, Mr. V. Watlington, who had been succeeded by Mr. B. H. Leeson. Mr. Watlington had, he said, been elected a Vice-President of the Association, as a mark of his outstanding service to the Association and the electrical industry. At the close of the meeting a presentation was made to Mr. and Mrs. Watlington. The opinion of the Council was that the industry did not fear any fair competition from the Central Authority to be set up under the Government's Electricity Bill, because it was efficient, progressive and capable of meeting overseas as well as home demands and could offer economic terms and experienced service, which should discourage the Central Authority, as it had done the electricity supply undertakings, from embarking on manufacture. At a subsequent meeting of the B.E.A.M.A. Council Sir George Nelson, chairman and managing director of the English Electric Company, Ltd., and Mr. E. C. Holroyde, vice-chairman of Crompton Parkinson, Ltd., were unanimously elected Chairman and Vice-Chairman for the next session. With regard to generating plant and equipment, the Council is confident that with adequate supplies of labour and materials all demands can be met. Recently, after discussion with the Prime Minister and the Ministers of Supply and Fuel and Power, it was announced that the Government was making arrangements to afford special priority to the production of generating plant and equipment. The Government Heavy Electrical Plant Committee, established early in the war, has been reconstituted under the chairmanship of the Minister of Supply. Sir Harry Railing and Mr. C. K. F. Hague have been selected by the Minister of Supply to represent the Association on the Engineering Advisory Council. Proposals are now being formulated for the setting up of an Export Promotion Department of B.E.A.M.A. under Mr. D. Maxwell Buist, as Export Director. With the approval of the Board of Trade it is expected that this Department will take over the functions of the electrical industry export groups.

Revised Regulations for Whitworth Scholarships

The new regulations for the Whitworth Scholarships offered by the Ministry of Education for competition in 1948 have now been published by the Stationery Office. Two Whitworth Senior Scholarships, valued at £325 and tenable for two years, and five Whitworth Scholarships of a minimum value of £200 each, tenable for three years, are to be offered. In addition, there will be ten £20 prizes to be awarded to unsuccessful competitors whose work deserves recognition. The conditions governing the candidature for the five Whitworth Scholarships have now been altered in two main respects. Candidates must have completed 24 months of works training, instead of 30 months as hitherto, and while entry is still limited to part-time students, an apprentice is eligible to compete if released for part-time study up to 600 hours each year, as compared with the 320 hours specified in the old regulations. The Ministry of Education Science Scholarship examinations in engineering will still be used for the purpose of making the awards, but the conditions have been amended. Candidates will be required to reach a certain minimum standard in the two qualifying papers in mathematics and applied mechanics and will also be required to take three Scholarship papers chosen from a number of alternatives. Workshop technology is introduced for the first time, as one of these subjects. In the past, entries for the Whitworth Senior Scholarships were governed by the same conditions as for the Whitworth Scholarship, and university students often could not qualify because of the practical training conditions. It has now been decided that a candidate can enter for a Senior Scholarship without having covered the specified period. If successful, however, the candidate must spend at least one year in a works, to gain practical experience before taking up his Senior Scholarship. During that period he may receive a grant not exceeding £50 over and above the value of the scholarship. The formal examination papers are done away with, and have been replaced by a written thesis on one of a number of subjects. These will be reviewed from year to year and announced about eighteen months before the closure date for entry. Among the eight specified subjects for the 1948 competition, the following are included: Gas Turbines, Industrial Heating Plants, Modern Developments in Fine Measurements, and The Use of Electrical Methods in Mechanical Measurements.

Lloyd's Register Shipbuilding Returns

The statistics issued by Lloyd's Register of Shipping, regarding merchant vessels under construction at the end of March last, show that in Great Britain and Ireland there is an increase of 94,653 tons in the work in hand as compared with the figures for the previous quarter. The present total of 2,031,715 tons gross, which is also greater by 355,612 tons than the tonnage which was being built at the end of March, 1946, has not been exceeded since March, 1922, when the total recorded was 2,235,998 tons. At the end of March the tonnage upon which work was suspended amounted to 2260 tons. The tonnage intended for registration abroad or for sale stands at about 513,000 tons or about 25·3 per cent of the total being built in this country. The tonnage of merchant vessels under construction abroad at the end of March is shown as 1,711,600 tons gross, which is 29,819 tons less than that recorded at the end of December last. No figures are included for Danzig, Germany, Japan, Poland and Russia, but the information concerning France is more comprehensive than previously. The total tonnage under construction in the world, apart from those countries excluded, as mentioned above, amounts to 3,743,315 tons gross, of which 54·3 per cent is being built in Great Britain and Ireland, and 45·7 per cent abroad. During the quarter under review, in Great Britain and Ireland, 294,902 tons were begun, and 270,543 tons launched. Similar figures for abroad are 167,449 tons begun, and 109,075 tons launched. Steam and motor oil tankers of 1000 tons gross and upwards under construction in the world amount to sixty-four vessels of 563,597 tons, thirteen steamers of 112,850 tons, and fifty-one motorships of 450,747 tons. Of the total under construction in Great Britain at the end of March 1,064,562 tons consisted of steamers and 958,581 tons of motorships. At the same date the tonnage under construction abroad comprised 545,158 tons of steamers and 1,166,562 tons of motor vessels. At the end of March, 2,340,866 tons or nearly 63 per cent of the merchant shipbuilding in hand throughout the world were being constructed under the supervision of Lloyd's Register. Of that total, 1,671,826 tons or more than 82 per cent was under construction in Great Britain and Ireland, while of the tonnage being built abroad, 669,040 tons or more than 39 per cent, are being constructed under the inspection of Lloyd's Register.

Lord McGowan on British Industrial Problems

The industrial problems of this country were discussed in a speech by Lord McGowan, which followed the annual luncheon of the Machine Tool Trades Association in London, on Wednesday, April 16th. He dealt to some length with the question of fuel shortage. In the course of his remarks he pointed out that collieries alone take nearly eleven million tons of coal per annum, or one-sixth of all used by industrial concerns, for their own running, and suggested that there should be room for major economies in colliery usage in the light of modern development. With regard to the fuel used in his own group of companies, data showed that there had been a drop of 5·6 per cent in calorific value from 1939 to 1946, and using this figure as a basis it represented an effective loss equivalent to 10,000,000 tons of coal on the output of 1946. For this reason, Lord McGowan considered that pressure should be put on the Government to publish figures of calorific value and the actual output of coal should refer to some standard calorific value as a basis. The speaker urged that a far closer relationship should be promoted between managements and workers in this country. The workers should be informed of the market problems and difficulties with raw materials experienced by employers, and given a truer understanding of industrial policy at home and abroad. He believed that industrial managements could do a great deal more to promote individual and national health and wellbeing, particularly in the larger concerns. In his concluding remarks, Lord McGowan said that if only coal, and hence steel, supplies could be assured, then he could not see unemployment of a general character for many years to come. Unfortunately, he was of the opinion that there will be much unemployment during the autumn and winter of this year, which will continue until we are assured of sufficient supplies of coal and steel.

Sheet Pile Corrosion at Port of Copenhagen

By MOGENS BLACH* and AXEL ROGBERG†

DURING the last thirty years or so, steel sheet piling has been extensively used for quay wall construction in the port of Copenhagen. Nearly 9000 linear metres of various types of wharves with steel sheet piling as the retaining element have been constructed at water depths varying from 2 m to 10 m. The costs of sheet pile construction were comparatively low, and in general no appreciable expenses have been involved for maintenance. In fact, the only point of uncertainty has been the durability of the piling, and in order to obtain a good estimate of it, based on experience, a series of measurements and tests has been made to determine the extent of corrosion.

The examinations made fell in two groups, viz., direct measurement of the reduced thickness of the sheet piling; and tests with samples of piles submerged in the harbour. The direct measurements appear to be of more interest, but for various reasons the results of the second series of tests are desirable as supplementary data.

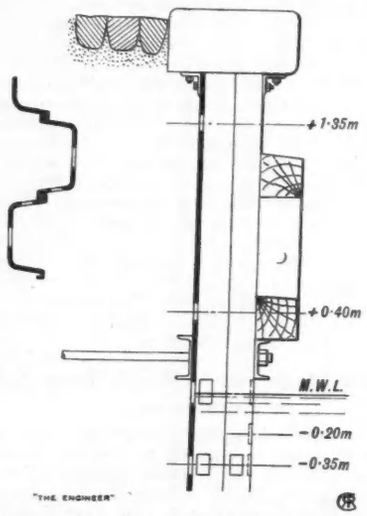


FIG. 1—SECTION THROUGH QUAY WALL

Examination of Existing Piles

During 1938–39 and 1943–45 the steel walls along the western and eastern quays of the "Kalkbrænderihavn," in the northern section of the port, were examined. These wharves were built in 1916 and 1917, respectively, and are the oldest steel sheet pile walls in the harbour.

At the same time similar examinations were made in other parts of the port. The wharves in these places, however, are of later date, and, as in all the tests, the intensity of the corrosion is deduced from the difference between the catalogue dimensions and those found by measurement, uncertainty with regard to original thicknesses due to rolling variations affects the results to a greater extent in the case of sheet piling driven more recently than in the case of piles undisturbed for many years. Furthermore, since anti-corrosive coatings, with which the piles were treated before being driven, retard the commencement of attack to some extent, examination of the older walls gives a more correct picture of the conditions such as can be expected in the course of time. Consequently, the following report is confined to the results of examinations carried out at the "Kalkbrænderihavn." It was also convenient to do so, because a collision which took place along the eastern quay of this harbour necessitated the withdrawal of three piles, and thus an opportunity was afforded to make a particularly thorough local examination.

The construction of the wharf is shown in Fig. 1. The depth of the water is 6·3 m; the sheet piling is of Larssen type, old section No. IV (Fig. 2). The quay is provided with wooden fenders, and the top of the steel piling is covered by a coping of reinforced concrete. There is no tide in the port.

Results of Direct Examination

The following direct observations were made on the withdrawn piles:—

The rear of the piling was practically free of rust below 1 m under the water line. From there to the water line corrosion was in general superficial and in no places deep, whereas in several places above water—especially between 0·3 m and 1·2 m above—there were places with fairly deep corrosion. This advanced corrosion is probably due to sulphur compounds and other substances carried down by rain water from the quay, as the adjoining site is used for coal storage. It was noticed that siliceous sand, of which the backfilling consists, together with rust, had formed a hard and dense coating which acted as a protection against further rust attacks.

The surface of the piles showed a more or less uniform distribution of rust above mean water level. Below that point the piles were covered with fouling except on the webs, which presented large, bare and rusty areas over the greater part from about 0·15/0·20 m to about 2 m below the water level at the outer troughs, and to about 0·5 m below the water line at the inner troughs. In addition to sea grass, the fouling consisted partly of small organisms (*Cirripedia*) with calcareous shells of a cellular structure, and partly of mussel shells, which, however, only appeared at about 0·20 m below the water line. From the place where the piles enter the bottom to about 1·5 m above this point the fouling was appreciably lighter than higher up the piles.

Results of Measurements

Measurements were made both in the webs and in the legs. However, the corrosion was not even over the cross sections at the various depths, and as corrosion below the mean water level practically everywhere was greater in the webs than in the legs, we will confine ourselves to the measurements of the webs.

The results of measurements of the web of one of the inner troughs are illustrated in Fig. 3. The thicknesses in millimetres are plotted as abscissæ, while the distance in metres above or below the water line are marked by the ordinates. In all cross sections indicated the maximum and minimum thicknesses were measured. These are shown in comparatively thin lines, whereas the heavier line represents the mean thickness, *i.e.*, the average thickness of the corroded web along the whole of the pile. The corrosion is represented by the hatched area between the catalogue dimension and the reduced thickness as measured in 1943. It should be noted, however, that the original catalogue dimensions may have had margins of at least 0·4 mm.

Fig. 4 shows the corresponding results obtained from measuring the web of the outer trough on which there was only an opportunity of measuring from the water level to 4 m below the water line. The maximum corrosion here is considerably greater.

To illustrate the proportion of the cross sections most weakened by corrosion in relation to the bending stress, Fig. 5 shows the variation of the bending moments M corresponding to the angles of friction of 35 deg. and 30 deg. above and below the water line respectively, and the bending moments permissible per linear metre of wall along the sheet piling under examination, calculated on the basis of the reduced section modulus due to corrosion and r=1500 kg per square centimetre. In calculating the section modulus it has been assumed that the friction in the locks is sufficient to transmit the shear forces and to make the inner and outer piles act as a unit.

Sample Measurements

Except in the case of damaged piles, the normal procedure was to cut out at various places samples about 10 cm by 10 cm by means of flame cutters. The samples were cleaned and the average thicknesses determined, from which by comparison with the catalogue dimensions the average rate of corrosion was calculated. At each place samples were taken from two adjoining piles. Owing to the presence of the fenders the samples above water level were cut from the webs of the inner troughs; at water level and at the heavily corroded cross-section 0·35 m below water level, they were cut from both webs as well as the legs; and finally, some samples were cut from the web of the outer trough at depths down to 2·0 m below water level. No samples were taken below that depth, partly to save expense in connection with diving, and partly in view of the fact that, as mentioned later in connection with tests on submerged samples, it appeared that corrosion decreased at lower depths.

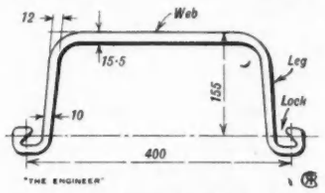


FIG. 2—SECTION OF SHEET PILE

Mean Annual Corrosion Rate

Height or depth of sample, metres.	Corrosion rate, millimetres.			
	Webs.		Legs.	
	Outer trough.	Inner trough.	Outer trough.	Inner trough.
+1·35	—	0·02	—	—
+0·40	—	0·06	—	—
Water level ...	0·01	0·03	—	0·02
−0·20	0·07	—	—	—
−0·35	0·19	0·15	0·12	0·08
−0·50	0·17	—	—	—
−1·00	0·09	—	—	—
−2·00	0·08	—	—	—

At the eastern quay the mean corrosion of the outer troughs amounted to 0·17 mm; at the western quay the corresponding figure was 0·21 mm. The table above gives the average annual rate of corrosion for the eastern and western quays taken together. In arriving at the figures the retarding effect

* M. Danish I.C.E., General Manager of the Port of Copenhagen.

† M. Danish I.C.E., Department Engineer.

of anti-corrosive paints was neglected, and it was assumed that corrosion took place uniformly with time.

Tests with Submerged Sample Piles

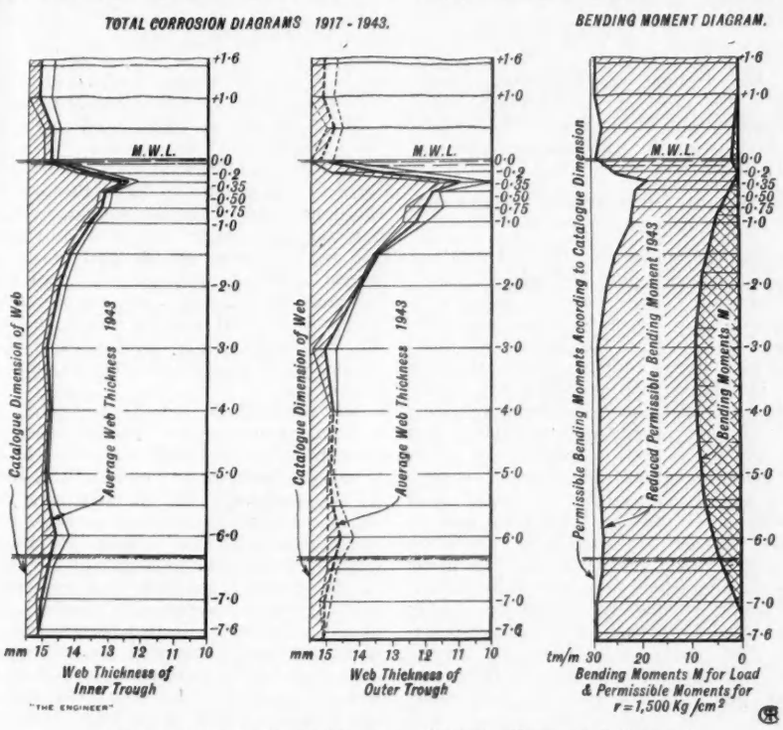
These tests were made by measuring periodically the loss in weight of certain samples of piles submerged in the harbour. The samples were short pieces of piles varying from 10 cm to 20 cm in length, all of them being of Larssen, old section No. IV. The sample pieces were weighed to an accuracy of 5 g and placed partly at the western quay of the "Kalkbrænderihavn," where the depth of water is 2·8 m, and partly near the "Langebro" bridge, in the southern section of the port, at a place where the depth was 5·0 m. Both at the "Kalkbrænderihavn" and at "Langebro" samples were hung at approximately water level and also respectively at 2·20 m and 4·45 m below water level. The samples were in three qualities: normal strength, higher strength and also of the former, but containing a small proportion of copper.

At intervals varying from one to six years, extending over a period of about twenty-one years in the case of the oldest samples, all test pieces were taken out of the harbour, thoroughly cleaned by hammering and scraping and then weighed for comparison with the weight found at the previous examination. The samples were then returned to their former positions. In this manner the tests were continued uninterruptedly up to 1938, when the examinations were brought to a conclusion.

On the basis of loss in weight, the average annual reduction of the thickness of the test pieces was calculated. The total test period for the normal quality samples was about fifteen years in the "Kalkbrænderihavn" and about twenty-one years at "Langebro." The tests with the higher strength and copper content pieces extended over a period of about twelve years, but the test pieces of the latter quality placed in the "Kalkbrænderihavn" at approximately water level were lost after about six years.

No great difference in corrosion resistance of the three qualities of steel piling submerged in the port of Copenhagen can be deduced from the results obtained by these tests. With regard to the intensity of corrosion, the test results give approximately the following annual averages respectively:—Depth: at mean water level —2·20 m, and —4·45 m; annual corrosion: 0·12 mm, 0·10 mm and 0·07 mm.

The results at the mean water level differ considerably from the direct measurements of the steel piling, which is probably mainly due to the fact that the lower parts of the large samples reach a good way below water level, which, on account of the great variation in the rate of corrosion below water, influences the result considerably. The other figures are somewhat higher than the results obtained from the walls, but this was also to be expected, because of the procedure adopted, by which the protective coating was removed whenever the test pieces were weighed. The tests were of most interest during the first years, because it is at that time that uncertainty as to the original thicknesses of the piles has the greatest influence on results of direct measurements. Nevertheless, the tests have acted as a guide as to the variation of corrosion in relation to the depth of water, and they afford a preliminary idea as to whether more expensive steel qualities should be used to obtain reduced corrosion. Moreover, such tests with submerged samples can be made at comparatively low cost.


TOTAL CORROSION DIAGRAMS 1917 - 1943.
BENDING MOMENT DIAGRAM.
M.W.L.
Catalogue Dimension of Web
Average Web Thickness 1943
Permissible Bending Moments According to Catalogue Dimension
Reduced Permissible Bending Moment 1943
Bending Moments M
mm 15 14 13 12 11 10
tm/m 30 20 10 0
Web Thickness of Inner Trough
Web Thickness of Outer Trough
Bending Moments M for Load & Permissible Moments for r = 1,500 Kg/cm²
"THE ENGINEER"

FIGS. 3, 4 AND 5—CORROSION AND BENDING MOMENT DIAGRAMS

Discussion of Results

In expressing an opinion on the life of steel sheet piling in the port of Copenhagen, where the average salinity of the water is 1·2 per cent, on the basis of the tests described above, it should first be emphasised that absolutely dependable figures require observations over still longer periods. It must also be taken into account that local conditions—for example, the effluence of diluted sewage water—may have influenced some of the measurements. Further, consideration should be given to factors such as wear and tear on the wharf caused by ice and waves, and also the position in relation to the cardinal points which may perhaps play a part in the degree of fouling. Further information on these factors will become available when other steel pile walls become somewhat older.

As a result of the examinations carried out to date, the following can be stated:—The heaviest corrosion is found in a belt 0·35 m to 0·50 m below the mean water level. From water level, where there is no particularly heavy corrosion, the corrosion increases heavily to about 0·35 m to 0·50 m below water, whereafter it again decreases so that it is considerably less at 1 m and still less at 2 m below water, from which point corrosion decreases more or less evenly downwards.

The corrosion is not uniform over the cross sections, especially in the area from 0·15 m to 0·20 m below water down to a depth of about 2 m below the water line. Here corrosion is considerably less in the legs than in the webs. It is characteristic of the oldest steel piles in the harbour that fouling occurs only to a limited extent from 0·20 m to about 2 m below water on the webs of the outer troughs and to about 0·5 m on the webs of the inner troughs. In the belt most heavily attacked the corrosion is approximately 25 per cent greater in the outer than in the inner web, and about 50 per cent greater than in the legs.

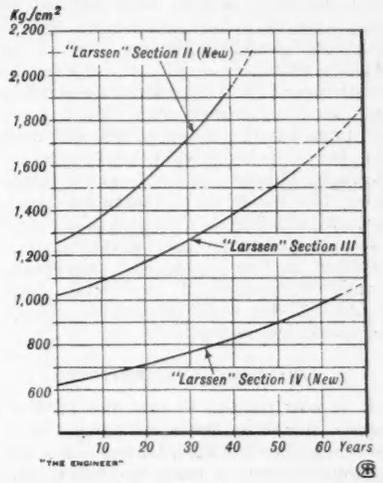


FIG. 6—BENDING STRESS OF PILING AT 7·5 M WATER DEPTH

A safe estimate of the maximum annual corrosion may be taken as follows:—0·20 mm for the web of the outer trough, 0·16 mm for the web of the inner trough and 0·12 mm for the legs. At a depth of 2 m or 3 m an average value of 0·08 mm annually may be asumed as most likely.

When suitable backfilling is used the back of the sheet piling will be only slightly attacked by rust, provided the tar coating is undamaged after driving.

On the face the attack above mean water level is generally not very deep, even when thick loose flakes of rust give the appearance of heavy corrosion.

So far no appreciable difference has been detected in resistance against corrosion for the various qualities of steel examined.

The heaviest corrosion and the corresponding weakening of the wall will not be found at the place where the bending moment of the wall is at its maximum, but often at the place where the bending stress is comparatively small (Fig. 5). In calculating the life of sheet piling, however, account must also be taken—apart from the static stress on the wall due to bending and shear—of the mechanical action to which the steel wall is exposed when ships are mooring. Damage

caused to the wall by ships' fenders, &c., is naturally dependent on whether the wall is provided with fenders (or quay superstructure) or not; but in order that steel piling may have the necessary resistance against deformation or failure, the thickness of the steel must not be reduced below a certain minimum, which, amongst other things, will depend on the size of the ships and the depth of water along the quay. Taking, for instance, ordinary steel sheet piling at a water depth of 7·5 m, the practical limit to which the wall may suffer corrosion will probably have been reached when the minimum mean thickness is 2 mm or 3 mm. As the actual thickness must, in places, be less than the mean, the consideration that there must be no local seepage of the backfilling will also be a factor in deciding on the minimum mean thickness.

The original web thickness of a Larssen section No. III is 14·2 mm, with a minimum thickness of 8·5 mm in the legs. At some place below water the web of the salient parts will be corroded to a mean thickness of 3 mm in the course of about fifty-five years, and the mean thickness of the legs will at the same time be reduced to 2 mm. The life of this steel wall may thus be assumed to be fifty-five years. It should be remarked that the stresses at the deeper and far less reduced cross sections, which are exposed to the maximum bending moment, will not at that time have reached a value greater than the allowable. This may be seen from Fig. 6, which shows the variation of maximum bending stress with the age of the sheet piling, on the assumption of an average annual corrosion of 0·08 mm at this depth, and provided the backfilling consists of sand with friction angles of 35 deg. and 30 deg. above and below the water line, respectively.

Economic Considerations

It is now natural to examine whether it pays to choose for this sheet piling a heavier section, as, for instance, Larssen sheet piling section IV (new), of which the web thickness and minimum thickness of the legs is 14·8 mm and 10 mm, respectively, which may be expected to have a life of about sixty-five years. The lighter section, Larssen No. II (new), the thicknesses of which are 9·5 mm and 7·5 mm, respectively, the life of which may be estimated at forty years, is not chosen in this instance, this section being somewhat too light for driving into the hard ground at the port of Copenhagen at 7·5 m water depth, but it will nevertheless be included in the calculation now following.

The cost of a wharf at 7·5 m water depth built of Larssen sections No. III to 2·0 m above water line is estimated at 2700 Danish kroner per metre (1946 price level), and the corresponding cost when the wharf is built of Larssen sections No. II (new) or IV (new) amounts to 2500 kroner and 2900 kroner per metre, respectively. The annual upkeep for a steel wall does not vary much with the age of the quay and, as it is rather low compared with the interest and depreciation charges, it is left out of account.

Depreciation over forty years of a Larssen wall No. II (new) will at a rate of interest of 5 per cent require an annual expense of $2500 \times 0{\cdot}0583 = 145{\cdot}70$ kroner per linear metre.

Depreciation over fifty-five years of a Larssen wall No. III will require an annual expense of $2700 \times 0{\cdot}0537 = 144{\cdot}90$ kroner per linear metre.

Depreciation over sixty-five years of a Larssen wall No. IV (new) requires $2900 \times 0{\cdot}0522 = 151{\cdot}40$ kroner per linear metre.

Section No. III is thus the cheapest. The capitalised difference in price between Larssen wall No. III and No. II (new) and No. IV (new) respectively, is 16·00 kroner and 130·00 kroner per linear metre of quay.

The annual charges at a rate of interest of 4 per cent are 126·30 kroner, 122·10 kroner and 125·80 kroner, respectively, and under this assumption a wharf in section No. III will be 105·00 kroner cheaper per linear metre than section No. II (new) and 93·00 kroner cheaper than section No. IV (new).

The reconstruction of a quay wall will, however, also entail the cost of removing the old one wholly or in part and the cost of surfacing. But these costs are only in exceptional cases so heavy that it will be cheaper to use sheet piling section IV than to use section III.

Corresponding calculations for sheet piling of Klöckner or of other sheet piling section will give results pointing in the same direction. A purely economic consideration will, at a fairly normal rate of interest under conditions as existing in the port of Copenhagen and with the ruling steel prices, generally lead to the result that it does not pay for the sake of resistance to corrosion to choose a heavier section of sheet piling than is necessary from considerations of driving qualities and observance of the Danish rules of good practice for the design and construction of works of this type.

The Institution of Naval Architects

No. V—(*Continued from page 336, April 18th*)

ON the evening of Thursday, March 27th, the meeting was resumed under the chairmanship of Sir Stanley V. Goodall. The first paper to be considered was by Mr. R. Baker and was entitled:—

Notes on the Development of Landing Craft

Captain Todhunter said that all who had served in landing craft had felt that they could radically improve the design, the armament, the amenities, the accommodation, and so on. The result was that, in the early days at any rate, the authorities were inundated with proposals for alterations, many of them exceedingly valuable, many of them utterly impracticable. Any proposals for alteration, particularly when the mass-production stage was reached, meant an immense amount of trouble and dislocation. It was his unenviable task to decide whether any particular alteration should or should not be made. In many cases the alterations were proved by experience to be completely necessary; if any were turned down, then one had the responsibility that men's lives might be thrown away, whereas by agreeing to them one might put back the whole programme. On the whole, however, the balance was reasonably well held between the D.N.C., the shipbuilders and those concerned on the operational side. From the Naval point of view a tremendous debt was due to Mr. Baker.

Mr. A. J. Merrington commented on some of the interesting operational features of the principal craft. Later, speaking of the German landing craft, he said he had seen a number of the German L.C.T.s in North Africa and the low countries, and in his view they were very substantially inferior to any of the British designs. They were a little faster, but rather narrow-gutted, and he certainly preferred the British type. As to the German invasion fleet, he said that on seeing a number of converted barges in the low countries one realised that the Germans were planning the assault on this country in a manner which was wholly amateurish as compared with our assault with the splendid set of landing craft we had at the end of the war. It seemed that the Germans had intended to use, very largely, river and canal barges, large, hefty vessels with no sub-division, no double bottoms, no double walls, and they looked very primitive. He believed they would have been absolute "meat" in any sort of attack, particularly if they had carried the heavy loads they could have carried, up to 1000 tons or so; undoubtedly there would have been very heavy loss of life.

Mr. J. M. Murray commented on the success achieved in the erection of landing craft with prefabricated parts in riverside yards. In a tribute to Mr. Baker, he said the programme of the development of landing craft was carried out with enthusiasm and by hard work on the part of all concerned. But enthusiasm and hard work were not quite enough; a spark of imagination was wanted and he could say that Mr. Baker had supplied that spark of imagination which was so necessary to complete success.

Mr. Barnaby (Messrs. Thornycroft), in a written communication, recalled the reference in the paper to the suggestion he had made in 1941 for a small double-ended L.C.T., and said that at that time both Mr. Baker and himself were a little pessimistic about each other's ideas. Mr. Baker's qualms were about the longitudinal stability of Mr. Barnaby's design, and the latter's trepidations concerned Mr. Baker's bow doors and ramps. He had been so nervous about the bow doors that he had wanted one at the after end also—to let out all the water coming in at the bow! Mr. Baker's qualms had to do with the free surface that might result. Anyway, Mr. Barnaby's fears were groundless, for Mr. Baker was able to design bow doors which had kept out the Channel, the Mediterranean, the Atlantic and the Pacific; for that he deserved great credit.

Mr. I. E. King, referring to the L.C.T. (4), which were designed for short-distance operation across the Channel, said that the first serious troubles they had met with were at the end of their long journey to Algiers, in order to join in the Sicilian operation in 1943. Only two of them had come to grief, however, so that the ultimate operations were not embarrassed seriously by the troubles that were encountered. But the fact that they had had such a serious shaking *en route* had presented the maintenance bases with a tremendous task. The craft had turned up in sufficient numbers to deal with the Sicilian landing, however, and they were very excellent craft for that purpose. The L.C.T. (3) were more reliable; they drew more water, and they were the more suitable to be sent back to take part in the Normandy landing. Thus, they had made the double journey. The L.C.I. (L) were fitted with variable pitch propellers; and inasmuch as one of the most vulnerable parts of a landing craft from the operational point of view was the propeller, he had been

surprised to find that those propellers were fitted. He understood the reason was the bottleneck in the production of gearing for ships in the United States.

Mr. Thornycroft, after referring to the development of amphibious craft in this country, said it seemed that the Ministry of Defence would have to make a decision as to whether the Navy or the Army were going to develop the amphibious craft of the future, having either tracks or pneumatic tyres. He felt it was a mistake to have two Departments working on the same lines. Having a little knowledge of the problems connected with tracked vehicles, he felt that the Navy would be well advised to leave the development of those craft in the future to the Army, who had gained great experience from the use of tanks and of very heavy artillery tractors using the largest size pneumatic tyres.

Mr. Baker, in his reply to the discussion, said that one could easily write a book on what landing craft had done apart from what they were intended to do; the adaptability of landing craft to all kinds of purposes other than those for which they were originally intended would enable one to cover a very wide field. In writing the paper he had tried to deal only with factual matters.

The Chairman said that the idea of landing craft on the floating dock principle had occurred in the heads of three different people at about the same time; they were Mr. Woollard (who was Sir Stanley's Assistant Director in charge of landing craft), Mr. Baker and a German designer. A very great debt was due to Messrs. Thornycroft, to the Americans and to Mr. Baker.

A paper entitled:—

NOTES ON DEPOT AND REPAIR SHIPS,

by Mr. H. E. Skinner, was then presented.

Mr. J. M. Murray said the paper showed clearly how in certain respects the Royal Navy in time of war had to rely extensively on the Merchant Navy. Of the twenty-one ships mentioned by name in the paper, only six were designed primarily for the work they had to do; the remainder were converted merchant ships. The facts proved that a merchant ship was a merchant ship and a warship was a warship, and that it was very difficult, if not impossible, to make a merchant ship which could readily be turned into a warship.

Mr. S. D. Dale dealt chiefly with the arrangement of workshops, &c., in H.M.S. "Ranpura." Succeeding speakers devoted their remarks mainly to the question of stability in merchant ships converted for naval duties.

At the final session, held on Friday, March 28th, under the chairmanship of the President (Admiral of the Fleet, Lord Chatfield), the first paper to be presented was entitled:—

RESIDUARY STABILITY,

and was contributed by Professor C. W. Prohaska.

Professor A. M. Robb said that for many years he had asked people how they plotted stability curves, and he had never yet obtained a satisfactory answer. His feeling was that the day of the stability curve had passed with the sail; it was a relic of the sailing ship era carried forward into the mechanical era. The stability curve was necessary for sailing ships, partly because we needed to know the angle of steady heel, and partly because we needed to know the angle to which the ship might heel under a squall. For those conditions we needed the stability curve right to the end; but a stability curve right to the end had no meaning for an ordinary steamer. Having obtained the stability curve up to the deck-edge very closely, one knew that, by and large, the maximum stability was twice the stability of the deck edge and the maximum angle was twice the angle of the deck edge.

Professor L. C. Burrill, dealing with the question of errors suggested that, in order to avoid the possibility of different kinds of G.Z. curves coming from different shipyards, there might be introduced a standard method. Further, the approximate estimates of the stability curve which Professor Prohaska had put forward should be laid alongside them; and he believed it would not be long before the first was dropped and the estimate of the stability of a ship was based on the second type of simple calculation rather than the longer calculation.

Mr. E. A. Brokensha agreed with the remarks of Professor Robb concerning the importance of the stability curves up to the immersion deck edge, except that cases were known of steamships, as distinct from sailing ships, capsizing suddenly. One case was that of a French vessel, when some 600 passengers on the deck had moved across to the leeward side, and the ship had listed to a very considerable angle. Trying to get back to harbour, the ship had changed course, but it was struck by a squall and apparently had turned right over. So that he imagined there were cases in which the stability above the immersion deck edge was very important. He disagreed with Professor Burrill that we should try to standardise our methods of calculation of stability curves as between the various shipyards, because if there were any error at all in the stability calculations it would apply to all. Let us have all the methods and try to be as accurate as possible with our calculations. We should then achieve a better result than by sticking to one method.

Dr. G. S. Baker, commenting that at the beginning of the paper the author had suggested that the cross-curves should be given to ships' officers, said it would be all right to give them the curves as supplementary to what was generally known as the standard stability data chart, which contained the curves of stability enabling any ship's officer to calculate where the centre of gravity would come and what the stability would be; but it would never replace those diagrams. They must guide an officer to where he wished to go, and not leave him to guide himself; that was all right in a university or even in an office, but they could not expect a ship's officer to work out curves of stability.

Professor Prohaska, in a brief reply, said he regarded stability curves as being essential for other ships as well as sailing ships; after all, quite a lot of ships had capsized during this century. He did not think it was necessary to make ships' officers do the calculations; it was only a question of giving them the curves as a matter of information.

The concluding paper was entitled:—

STRAIN AND BREAKAGE RECORDING ON H.M.S. "VANGUARD" DURING LAUNCHING, NOVEMBER 30TH, 1944,

and was presented by Mr. D. M. Baker.

Mr. D. E. J. Offord (Naval Construction Research Establishment) said that at the time of the launch of the "Vanguard," the Naval Construction Research Establishment was very young. They had attempted to make very complete records of strain and breakage. They had tried to run before they could crawl; but the effort was well worth while. It was agreed that the builders, Messrs. John Brown, should measure the motion of the ship down the ways, and that N.C.R.E. should confine their measurements to what happened in the ship. Unfortunately, the link between the John Brown and the N.C.R.E. time-scale had failed.

The primary and original aim of the operation was not to obtain launching data, but to use the launch to obtain measurements of stress concentrations at selected positions in the ship. The paper recorded the results obtained with the mechanical strain gauges. It was intended that those should serve mainly as a check to the readings from some 100 wire-resistance strain gauges. Those gauges were installed and wired up, but, unfortunately, did not give reliable readings. The experiments had shown vividly the great difference between a technique which was successful in the laboratory and one which would be successful under ship-board conditions. In brief, they had obtained no records, but they had obtained some very valuable experience.

Similarly, the breakage readings had fallen far short of what had been hoped for, and the technique needed to be improved. Automatic recording was essential, and as it was rarely possible to get a reasonable sighting line along the centre of the ship, two balanced sighting lines were necessary, so that, in the analysis, they could separate twist from true breakage.

For the launch, N.C.R.E. had to supply between twenty or more gauge positions, an intercommunication system, including telephones, loud speakers and time signals; they had also to fit auxiliary lights and a power supply to operate them. The recorded results had been analysed by Mr. Baker in one particular manner. It was obvious that there were many other methods of analysis, and some of those would have been used if more complete records had been obtained.

The extent of the vibration which occurred when the ship left the end of the ways was, to Mr. Offord at least, a little surprising. He referred to one of the diagrams which showed that it was sufficiently violent to cause a mean stress of nearly 1 ton per square inch. He regretted particularly that the wire resistance gauges were not working at that time to give some idea of the stress concentration factors under that condition which approached to some degree the conditions ruling when a ship was shaken by an underwater explosion.

N.C.R.E. hoped eventually to evolve a technique and to obtain a suitably trained staff to secure fairly complete records during the launch of all large warships. Such records would, in time, he hoped, form a very valuable contribution towards a more complete understanding of the longitudinal strength of ships, and how the forces acting upon them were distributed about the structure.

Mr. Baker endorsed Mr. Offord's point that a continuous system of breakage recording was desirable; and he added that it was due only to the level heads of the people taking the breakage measurements that they had been successful at all. They had an illuminated slot, and in the event that illuminated slot was moving up and down the sight so quickly that they never obtained the maximum readings. The method was not really satisfactory. He had not included in the paper the vibration curves obtained, mainly because he did not think they were of general application. Any information which came out of it would be applicable only to the "Vanguard" immediately she was launched, and not to any other ship.

The Physical Society's Exhibition

No. III—(*Continued from page 331, April 18th*)

WE continue our account of the Physical Society's Exhibition (London, April 9th to 12th) with brief references to a further selection of exhibits in both the research and trade sections.

Ferranti, Ltd.

An interesting exhibit demonstrated in the trade section by Ferranti, Ltd., Hollinwood, Lancs, uses the thunderstorm recorder—an equipment designed for the detection and recording of atmospheric discharges. The apparatus has been developed primarily to assist the operating personnel of power systems in safeguarding electricity supplies during thunder-storms, but in addition, the equipment is admirably suitable for use in laboratory investigations. When it is used for the former purpose, the recorder provides information quickly and simply giving sufficient warning of approaching thunderstorms (amounting to several hours in some instances) to allow the operating staff to take suitable precautionary measures.

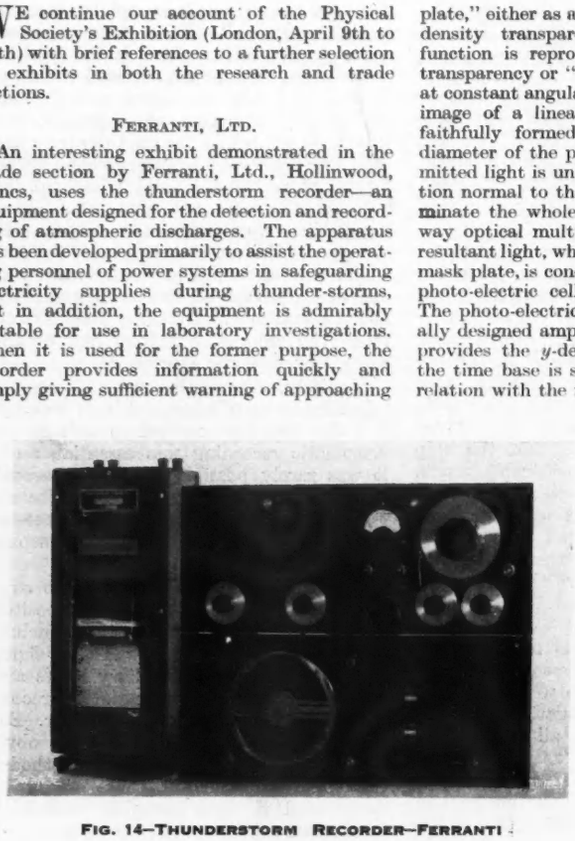


FIG. 14—THUNDERSTORM RECORDER—FERRANTI

In principle, the recorder is a calibrated radio-receiver, using an ordinary outdoor aerial and giving a continuous record of atmospherics on a chart. As shown in Fig. 14, the apparatus consists of two separate elements. On the right of the illustration is the receiver with its controls. The recording milliammeter on the left forms the recording element. The approximate distance of the storm centre can be deduced from the chart record, while the severity of the disturbance can be assessed from the number of lightning flashes which are indicated on the two counters which can be seen on the lower panel of the receiving instrument.

The recorder is simple to operate. The controls include arrangements whereby the triggering level can be adjusted separately. Calibration of receiver sensitivity and counter triggering level is provided by a self-contained feed-back oscillator. The apparatus is a.c. mains operated and incorporates mains interference filters.

Another piece of apparatus, the photo-electric integral transformer, was developed jointly by Ferranti, Ltd., Crewe Toll, Edinburgh, and the Department of Mathematical Physics of the University of Edinburgh. This instrument, which was exhibited in the research and educational section, is capable of depicting instantly on the fluorescent screen of a c.r.t. the transform $g(y)$ of any analytical or empirical function $f(x)$, with reference to any suitable generating function of the form $\psi(xy)$, according to the general relation

$$g(y) = \int_{-\infty}^{\infty} f(x).\ \psi(xy).\ dx,$$

where y is a periodic function of time.

The function $f(x)$, within finite practical limits $a < x < b$, is reproduced on a "mask plate," either as a variable area or as a variable density transparency, while the generating function is reproduced as a variable density transparency or "pattern plate," which rotates at constant angular velocity. The incandescent image of a linear tungsten filament lamp is faithfully formed on, and coincides with, a diameter of the pattern plate, while the transmitted light is uniformly spread out in a direction normal to that of the image, so as to illuminate the whole of the mask plate. In this way optical multiplication is effected and the resultant light, which is transmitted through the mask plate, is condensed on to the cathode of a photo-electric cell and is thereby integrated. The photo-electric current is fed into a specially designed amplifier, and the output voltage provides the y-deflection of the oscillograph; the time base is sinoidal and is in fixed phase relation with the rotation of the pattern plate.

Provision is made in the optical and electrical channels for dealing with functions $f(x)$, which have both positive and negative values within the desired limits of integration.

The pattern plate rotor is so designed that interchange of pattern plate transparencies can readily be made, while a number of standard mask plates provide means for rapidly checking the overall accuracy of the instrument.

Important applications of the instrument include the derivation of Fourier transforms, involving a phase constant, and Laplace transforms, involving the use of an exponential variation in pattern plate transparency. Many other useful applications may be found in pure and applied physics, in X-ray crystal analysis, in transient phenomena in mechanical and electrical engineering (including servo mechanisms and circuit analysis) and in statistical analysis.

B.T.H. Research Laboratory

Crystal rectifiers which were developed for use in centimetre-wave radio and radar equipment can be used outside the centimetre wave band for many purposes, where size, mechanical strength and absence of heater connections are important considerations. Some of these applications formed the subject of exhibits shown by the research laboratory of the British Thomson-Houston Company, Ltd., Rugby.

One example was a rectifier voltmeter incorporating capacitance dividers for extending the voltage range. Without dividers the instrument has a range of 0 to 50 V from 50 c/s to 5 Mc/s. By using the appropriate voltage dividers the range can be extended to 250 V, 1000 V, 5000 V and 10,000 V respectively over the frequency band 200 kc/s to 5 Mc/s. A special feature of the design is the double circuit, symmetrical with respect to earth, which allows measurements to be made of the voltage between two points when either point or any intermediate point is earthed, and, at the same time, maintains the d.c. circuit and the meter case at earth potential.

Another instrument demonstrated was a radio-frequency current meter adaptor, comprising a toroidal input transformer and a crystal rectifier. This unit, when used in conjunction with a 0 to 1 mA d.c. meter, is calibrated to read 0–1 A over the frequency range 95–105 Mc/s. Other frequency ranges can be covered by suitable design of the input transformer.

The B.T.H. Company is actively interested in developing the promising possibilities of silicone insulations. Progress in one particular direction was demonstrated by an exhibit consisting of a three-phase, 3000-r.p.m., squirrel-cage induction motor with silicone insulated stator windings. The motor was running on a load of approximately ½ h.p., giving a temperature of approximately 175 deg. Cent. on the windings. For exhibition purposes the machine was mounted in an open test frame to allow the windings to be readily inspected.

The insulation consisted of silicone-treated glass cloth slot liners, silicone-treated glass tape on the end windings, glass insulated wire and glass insulated flexible leads, and the completely wound stator was impregnated in silicone varnish. In view of the high temperatures for which the winding was designed, all joints between the coils and between the winding and outgoing cables were welded or brazed, no soft solder being used. All the silicone materials used in the motor were developed and made in the B.T.H. research laboratory, and various samples of the insulations were exhibited.

It is to be expected that silicone insulation will be used primarily in motors where the severity of the duty or the conditions of operation are such as to give rise to excessive temperatures. Silicone-insulated motors of a given output rating will generally be appreciably smaller than the equivalent standard motor of to-day, because silicone materials will withstand a higher operating temperature. In aircraft, therefore, and in other situations where space is restricted, it is evident that there is a useful field of application for machines using silicone insulation.

Londex, Ltd.

The photo-electric control equipment that was exhibited by Londex, Ltd., 207, Anerley Road, London, S.E.20, is of more than usual interest at the present time because the instrument incorporates a voltage stabiliser to counteract the effects of mains voltage fluctuations. As illustrated in Fig. 15, the equipment forms a convenient and compact unit for controlling street lighting automatically when daylight fails.

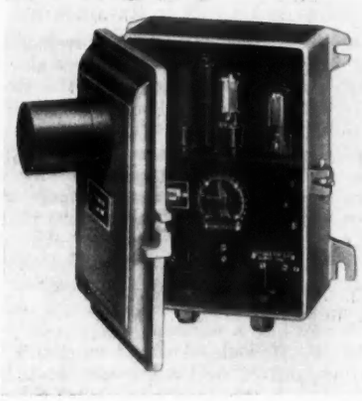


FIG. 15—PHOTO-ELECTRIC EQUIPMENT—LONDEX

Essentially the instrument consists of a photo-cell, a cold cathode valve and a stabiliser tube. The photo-cell operates the cold cathode valve, which has no filament so that only the h.t. supply requires stabilisation. The h.t. voltage is approximately 100 V, being derived by half wave rectification from the mains supply without the necessity for using a transformer. By arranging that all valves are underrun, and by using a cold cathode tube instead of a triode, long life of the expendable components is ensured, and the makers claim that, with the exception of the projector lamp, the equipment will give approximately three years' service without replacement.

It is stated that the apparatus has a maximum sensitivity of approximately 1 foot candle with white light. This order of sensitivity, together with the inherent voltage stability of the equipment, makes it particularly suitable

for the automatic control of street lighting and there is no tendency for the instrument to "flutter" when the mains voltage drops after the lights have been switched on. Other applications for the instrument are suggested by the fact that an infra-red screen can be fitted to the projector, cutting out the visible light and making the unit sensitive to infra-red radiation.

Atomic Energy Research Establishment

The exhibits of the Atomic Energy Research Establishment represented the activities of the electronics groups working at the Telecommunications Research Establishment, Malvern, and were principally concerned with health monitoring instruments and the electronic apparatus used for measurement and calibration generally.

A demonstration was given of four pieces of equipment that are used for determining the characteristics of Geiger-Muller counters. Included in this group of equipment was an automatic plateau plotter which records on a strip of paper any variation with applied voltage in the counting rate of a Geiger counter. This measurement provides a useful check on the reliability of a given counter and can be used for the routine checking of individual counters.

The second equipment was a cathode ray monitor with a pulse interval discriminator. This instrument consists of a cathode ray monitor which is triggered by the pulse from a Geiger counter and displays the pulse on the cathode ray tube. The pulse interval discriminator ensures that the monitor is only triggered by pulses which have been preceded by a pulse-free interval of such a length that there can be no ions in the Geiger counter due to a previous striking. In this way a steady picture is obtained. This apparatus is useful for the general checking of Geiger counters and it can be used for measuring pulse amplitude as well as for estimating dead time and recovery time.

A separate equipment, the dead-time indicator, gives an automatic measurement of the time during which a Geiger counter remains insensitive after extinction of the discharge. Fully recovered pulses (as sorted by the interval discriminator) open a gate for a period much greater than the expected dead time. Any subsequent pulses, which have reached a pre-set fraction of the full amplitude before the gate closes, are passed through the gate. These then operate a circuit which narrows the gate by a small amount (about 1 microsecond) for each pulse passing. Equilibrium is reached when the gate period is just long enough to include an occasional pulse of the pre-set amplitude. The width of the gate is then nearly

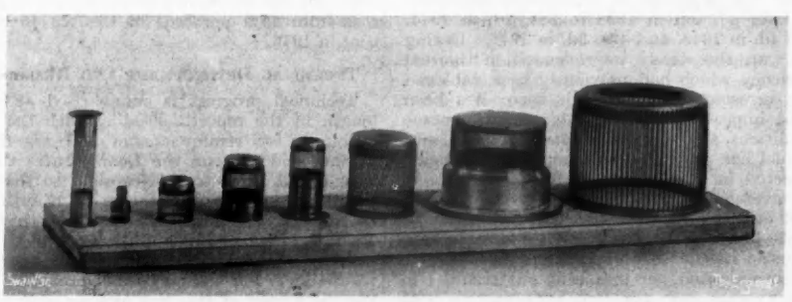


FIG. 16—SQUIRREL CAGE GRIDS—G.E.C.

equal to the time of recovery to the pre-set amplitude and this gate width is recorded on a meter. The accuracy obtained is of the order of ± 2 microseconds in 100 microseconds for counting rates of 5000 per minute and the measurement takes from one to two minutes.

The fourth instrument in this group is a pulse interval analyser, designed to detect any non-random distribution of the pulses given by a Geiger counter. Since most spurious counts are of a non-random nature, the presence of such counts can be detected and their time relationship with true counts ascertained.

As designed, the circuit counts directly the occurrence of intervals of time between t and $t + dt$, where t can be adjusted to any value between 50 and 670 microseconds, and the tolerance dt has a range of pre-set values from $2\frac{1}{2}$ to 20 microseconds.

G.E.C. Research Laboratories

An interesting demonstration of the absorption of millimetre radio waves by gases was given by the Research Laboratories (Wembley) of the General Electric Company, Ltd., to illustrate an important aspect of research into the propagation of micro-waves.

For the purpose of this demonstration electromagnetic radiation of 12·5 mm wavelength was produced by a magnetron generator and fed through a short-wave guide to a conical horn directed towards a concave optical mirror at a distance of a few feet. A glass flask containing ammonia gas was placed in the region of the focus of the mirror, the mouth of the flask being closed by a stretched rubber membrane. At this particular wavelength of 12·5 mm, which is the characteristic absorption wavelength for ammonia, the gas molecules absorb electromagnetic radiation, causing a change of pressure in the flask.

If, however, the magnetron output is modulated at audio frequencies the pressure changes will follow the modulating frequency. Under such conditions the rubber membrane acts as a diaphragm and the system functions as a transducer reproducing audibly the speech frequencies used in the modulation. Making use of a pure tone of 1000 c/s followed by gramophone records, the demonstration showed, in passing, that the system acting as a transducer was capable of reproducing speech recognisably.

That the system in its present state of development functions as a transducer is, however, of secondary interest. A much more important application is in the general exploration of the absorption bands in gases and vapours. Of particular practical interest are the absorption bands, in the millimetre region, for oxygen and water vapour, since these characteristics clearly have a close bearing on the possibilities and limitations of micro-wave transmission for radar and radio communication. A good deal of attention has been devoted to this subject, and preliminary details of research work carried out by the G.E.C. Research Laboratories, in conjunction with the Admiralty, were recently disclosed elsewhere.*

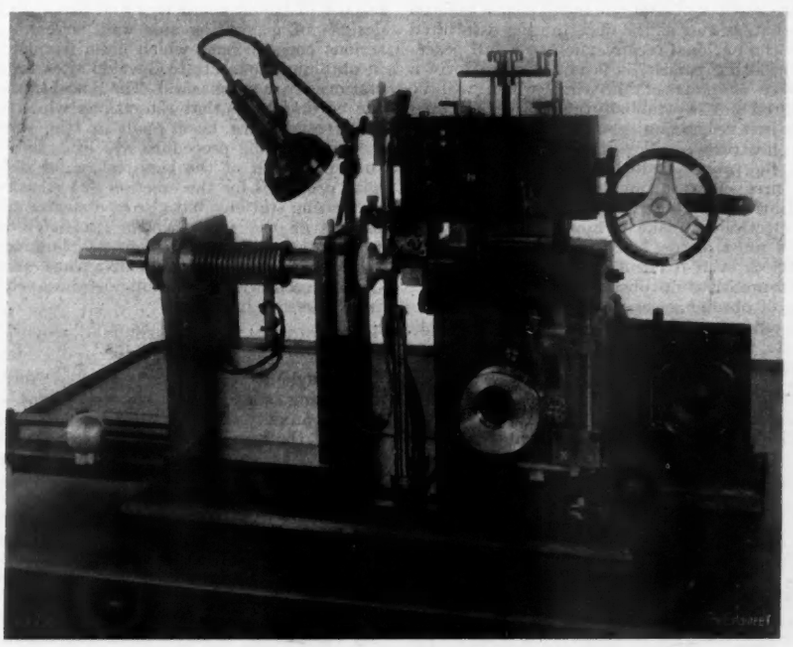


FIG. 17—AUTOMATIC MANUFACTURE OF SQUIRREL CAGE GRIDS—G.E.C.

Another exhibit on the same stand showed a machine that has been developed for the automatic welding of valve grids. In certain thermionic valves the grid structure is of squirrel-cage form, consisting of a number of spot-welded wires stretched between a cap at one end and a band at the other. Welding such grids manually is slow and laborious, particularly in the smaller sizes using very fine wires.

The machine demonstrated was developed primarily for use in the Research Laboratories. A measure of its usefulness is the fact that the machine can make squirrel-cage grids of a wide size range, as shown in Fig. 16 and in the following specification :—

Length of grid wire ...	...	$\frac{1}{16}$in to $1\frac{1}{4}$in
Diameter of grid cap	...	$\frac{1}{16}$in to $\frac{1}{4}$in
Diameter of grid wire	...	0·002in to 0·025in
No. of wires per grid	...	30 to 180

A general view of the machine with the covers removed so as to show certain details of the mechanism is reproduced in Fig. 17. The cap and band are placed on a spring-loaded mandrel, which, by the operation of a hand lever, is advanced to the welding head which occupies the centre of the machine. No other hand operation is required until the grid is completed. A molybdenum wire, fed from a reel and held in tension by diamond grippers, alongside the welding head, is spot welded to the band. The wire is then stretched and welded in position at the cap. Finally, the wire is cut by a hardened steel blade. All these movements, together with the welding process itself, are fully automatic. When one wire has been welded and cut, the mandrel makes the required angular rotation, and the cycle of operations described above is performed on the next wire. The process is automatically repeated until the grid is complete, when the machine switches itself off.

(To be continued)

* *Nature*, Vol. 158, page 943 (December 28, 1946).

Central Electricity Board

THE Annual Report of the Central Electricity Board, covering the year 1946, stresses the supreme importance of the highest possible degree of priority for the construction of generating stations in order that unrestricted supplies of electricity may be made available at the earliest possible moment. It is pointed out that, as long as the uncertainties associated with the national reconversion to a full peace-time footing persist, it is not easy to form a reliable estimate of the time which will be required to re-establish the normal balance between generating plant and the demand for electricity. Nevertheless, it is stated that the progress which was found possible in the first eighteen months after the end of hostilities, and the great increase in the demand for electricity, make it apparent that several years must elapse before the position can be rectified, even if effective measures are taken to ensure that no obstacles are placed in the way of obtaining consents to the construction and extension of generating stations, and the plant manufacturers and civil engineering contractors are given the fullest facilities for carrying out the work.

The Background to Load Shedding

The factors which have brought about this situation leading to the necessity for frequent

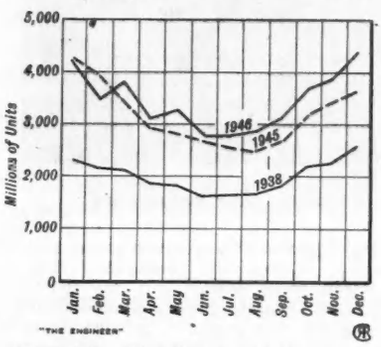


FIG. 1—ELECTRICITY GENERATED BY AUTHORISED UNDERTAKERS

load shedding are dealt with at length. It is pointed out that the principal reason for the rapid increase in the consumption of electricity during the latter part of the year, which is clearly shown in the accompanying diagram, was the shortage of coal, which stimulated the use of electricity for domestic and commercial heating. The report recalls that, during the war, the Government felt it necessary in the national interest to restrict the Board's programmes for the provision of additional generating plant and recognised that the inevitable result of that restriction would be a shortage in the supply of electricity in the immediate post-war years—a shortage for which the C.E.B. would not be held responsible.

In 1946, the increase in the demand for electricity exceeded the capacity of the new generating plant brought into service and on fifty-four occasions during the year, fifty-one of them in the latter half, it was necessary to shed load in order to avoid widespread interruptions of supply. The amount of load shed reached a maximum of 930,000 kW on December 16th, when some supplies had to be curtailed for as much as five hours. The Board states that load shedding on a greater scale and over longer periods will be unavoidable during the next two or three years, with a consequential dislocation of industrial production, unless means are adopted to spread the demand more evenly over the 24 hours, for instance, by arranging for a substantial transfer of industrial activity to a night shift or the re-arrangement of working hours so that some factories work a morning shift and others an afternoon shift.

Arrangements have been made for the construction of eighteen new stations by the winter of 1950, by which date an aggregate of 5,892,700 kW of new plant is due for completion. The report shows that a large measure of progress has been achieved in the standardisation of generating plant, both in respect of steam conditions and the sizes and designs of generating sets and boilers. The serious consequences which arise from delays in obtaining consents to develop sites for new stations are re-emphasised. The Board expresses the earnest hope that alterations which they understand have been made in the departmental planning procedure will lead, not only to a reduction of the time taken for dealing with proposals for the erection or extension of generating stations, but also to a clearer appreciation of the place which electricity must take in any effective system of planning, its requirements in order to fill that place, and the consequences which must follow if those requirements are not met.

Coal Supplies

Throughout 1946, coal supplies for the generating stations caused the Board even greater anxiety than in previous years. Before the war, the Board's aim was to start the winter with stocks equal to ten to twelve weeks' winter consumption. Early in 1946, the Ministry of Fuel and Power decided that the stock level at the beginning of the following winter must be cut to four weeks' consumption. The Board had no doubt that such a margin would prove insufficient and warned the Ministry that widespread interference with supplies of electricity was likely to occur. By the middle of May, stocks had fallen to a minimum level of 1,046,000 tons, representing an average of two weeks' consumption in the previous winter. The rate at which stocks were replenished was much slower than in previous years, and despite some reallocation of available supplies, the maximum stock reached, at the beginning of the winter was only 2,140,000 tons, as compared with 3,200,000 tons in 1945 and 3,555,000 tons in 1944.

The report again draws attention to the heavy financial burden imposed upon the electricity supply industry as a result of the flat rate increases per ton which have taken place since the outbreak of hostilities. Allowing for the increased costs of transport and handling charges, the average cost of fuel consumed at all the steam generating stations operated under the directions of the Board rose from 20s. 3d. per ton in 1938 to 38s. 7d. in 1944, 43s. 4d. in 1945, and 45s. 3d. in 1946. During the war, the steady improvement in thermal efficiency which had previously been achieved was arrested, and although there has been some improvement since the return to peace conditions, a further deterioration in the quality of fuel has prevented this improvement being reflected in a reduction in fuel consumption, the average for 1946 being 1·506 lb per unit sent out as compared with the 1938 figure of 1·430 lb per unit. The combined effect of the increase in the cost of fuel and the increase in consumption per unit sent out resulted in the average cost per unit sent out in 1946 being 137 per cent above that in 1938.

A diagram, reproduced herewith, shows how the pithead price per unit of heat supplied to the generating stations increased with the increasing ash content of the coal. This diagram relates to 253 consignments, totalling over 3,000,000 tons of bituminous coal supplied in 1945 from various coalfields and fired on chain grate stokers; all the consignments were, broadly, comparable in quality, apart from their ash content. It is stated that the freight and handling charges relating to this inert material in the coal, together with the subsequent ash-handling charges, result in an annual financial burden on the supply industry and their consumers of over £2,000,000. The loss of output capacity arising from the use of inferior and unsuitable coal on occasions exceeded 380,000 kW.

The Grid

At the end of the year, the number of selected stations associated with the Grid remained at 142. Their aggregate installed capacity was 11,588,306 kW, a net addition of 272,275 kW having been made during the year. The Grid itself comprised 5161 miles of transmission lines, of which 3675 miles are operated at 132 kV and 1486 miles at 66 kV, or lower voltages, and 348 switching and transforming stations having an aggregate transformer capacity of 13,920,200 kVA.

The total quantity of electricity generated at public supply stations in Great Britain in 1946 was 41,240 million units, or 10·6 per cent more than in 1945. During the year, 99·3 per cent of the electricity supplied by the authorised undertakers in the country (excluding North Scotland) was produced at stations, including forty-six non-selected stations, which were generating for the Board.

The maximum demand which was actually met by the Grid during the year occurred on December 18th, and amounted to 9,154,000 kW as compared with 8,653,000 kW in the previous year. The estimated maximum potential demand was 10,130,000 kW, and occurred on December 16th, but on that date, owing to a larger amount of plant being out of commission, only 8,961,000 kW could be carried, the remainder being shed. During the working days in December the plant out of service by reason of breakdown, overhaul, unsuitable fuel, &c., averaged 15·8 per cent

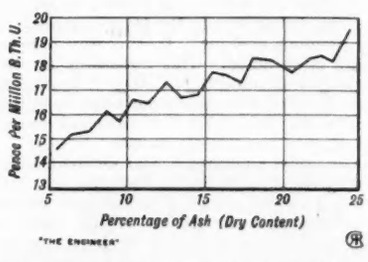


FIG. 2—ASH CONTENT AND FUEL COSTS

of the total capacity installed as compared with an average of 16·9 per cent in January, 1945, when the maximum demand in that year occurred. It is explained that the higher availability of plant in 1946 was largely due to improvement in the labour position at the generating stations, which resulted in a general reduction in the time taken to overhaul the plant. The load factor on the Grid System, based on the maximum demand actually met, rose from 45·1 per cent in 1945 to 46·6 per cent in 1946.

Technical Development and Research

Technical progress is summarised at some length in the report. Dealing with the programmes for reinforcements and extensions of the Grid system, the Board states that a new 132-kV line, from Neepsend to the proposed new generating station at Staythorpe, to reinforce the connection between the Mid-East and Central England Areas, is to be constructed so as to be suitable for later operation at 264 kV. For the purpose of providing data for the design of this line and possible higher voltage development, a 3-phase bank of testing transformers was ordered and will be used to test an experimental length of overhead line designed for operation at voltages up to 400 kV.

The Board refers to the close attention with which it has followed progress in gas turbines and states that the successful developments now taking place in this country hold promise of an important contribution to the problem of providing efficient economical and flexible plant to deal with the short-period peak loads which occur on public electricity supply systems. It is hoped in the near future to be able to arrange for the installation of one or more 15,000-kW machines of this type. The Board is also keeping in close touch with the

development of atomic energy for application to the generation of electricity.

During the year it was decided to construct a new research laboratory to provide increased facilities for the research development and routine testing work carried out directly by the Board. The plans for the new building have been completed and it is hoped that it will be possible to commence construction without delay. This laboratory will assist research into the special problems associated with the operation of the Grid. For research of a more general nature the resources of the National Physical Laboratory and of the British Electrical and Allied Industries Research Association will continue to be used.

The Board's accounts show that the gross receipts from the sale of energy during the year amounted to over £95,000,000, and that the credit balance of the General Purposes Revenue Account for the year was £6,408,080, which was less than in 1945 by £537,803. The overall cost to the electricity undertakers who received their supplies at the new Grid tariff introduced at the beginning of 1946 was some 3¼ per cent lower than would have resulted from the retention of the previous tariffs, representing a reduction in the price charged for those supplies amounting in the aggregate to approximately £585,000.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

COLD STARTING INTERNAL COMBUSTION ENGINES

SIR,—Your report in the current issue of THE ENGINEER of the Institution of Automobile Engineers' discussion on the cold starting of I.C.E.s (an appropriate abbreviation) recalls to my mind the first night I spent in Canada, in January, 1941, the coldest period of the year. On awakening in my 65 deg. Fah. heated bedroom I went to the window to get my first view of the Canadian winter landscape. The first thing I noticed, however, was a man approaching his snow-covered car in the hotel car park, where it had evidently been standing all night in a temperature of 10 deg. *below zero*. He just brushed the snow from the windows, stepped into the car and immediately drove away. It was not long before I learned that this is the everyday experience of motorists in Canada and U.S.A. In five winters spent in the very cold Province of Quebec, I saw only one car being cranked. Few drivers—and I questioned many—had ever cranked their engines, most of them did not know whether they carried a cranking handle and even less how to use it. It is true some owners throw a rug over the bonnet and many, but not all, use a radiator muff.

Many times I discussed this question of cold starting with Canadians. When I told them that in England we are taught to try to keep our engines warm, to use the crank in cold (in the English sense) weather, to run the engine a few minutes before getting under way, they would merely smile and wonder at our willingness to undergo such difficulties. (Probably they really wondered at our ignorance but were too polite to say so.) If I suggested that they were damaging their engines they would point out the number of very ancient cars on the roads, for, in spite of the belief prevalent in this country that Americans buy a new car every year, it is a fact that the proportion of old cars to be seen over there is at least as large as in this country.

Amongst the reasons put forward in explanation of their easy starting were such as their apparently superior carburettors and carburation; the fact that their cars are really "winterised" each late autumn, this including, *inter alia*, full use of anti-freeze solutions and the changing of all lubricants on the car (and I mean *all*); the grades of (*a*) fuel and (*b*) lubricants used; the almost universal use of 6-V batteries and the greater care bestowed on their batteries, and so on. To my regret, I have never discovered which, if any, of these is the true explanation. Or would it be merely the results of superior knowledge, design and experience? It would be interesting to have the views of those who put forward various stunts at the I.A.E. meeting as set out in your report.

Certainly Canadians do not, in general, make use of such methods, nor do they use ether starting capsules at 2s. 6d. per start. The fact remains, however, that in spite of their very much colder climate, they do not experience the difficulties in starting which are so common here.

What is the answer?

E. ARTHUR PINTO.

Birmingham, 24, April 20th.

THE STRANDING OF THE "QUEEN ELIZABETH"

SIR,—In view of the stranding of numerous vessels, including the "Queen Elizabeth," the following ideas are offered for your comment and criticism.

I was born within sight of the Goodwin Sands and as the many fine ships stranded thereon were usually lost through the so-called "suction" of the sands, it appears that if this "suction" could be destroyed ships could be freed with less difficulty.

The proposal is to destroy this suction by means of water jets forced through the ship's hull at points most likely to be affected by grounding.

In ships usually operated in dangerous waters a piping system could be built into the hull, or, alternatively, holes blanked off ready for attachment of such piping.

Where ships are not so equipped, an external application could be used by means of salvage vessels equipped with hydraulic pumps and suitable jets, from which a stream of water could be directed below sea level to the points where the hull was grounded.

I should be interested to hear if any such scheme has been considered and what are the objections if found impracticable. A sea captain told me many years ago that a flat-bottomed vessel with straight sides resting on wet sand or mud offered the maximum resistance to the rising tide, owing to the absence of any "lift" by the water. If this is correct, it would appear to confirm the need to destroy the contact as far as possible to enable the water to exert this upward pressure.

S. T. SAUNDERS.

St. Albans, Herts, April 17th.

[It is important not to confuse the two meanings of the word "suction." The classic case of "suction" between passing ships is that provided by H.M.S. "Hawke" and the liner "Olympic" in 1911. This form of suction, the hydrodynamics of which are well understood, can also be manifested between a ship and a bank of land or shoal which she approaches closely, and is a familiar occurrence in the case of a barge traversing a canal. Our correspondent, however, has in mind the suction between a ship's hull and the mud or sand on which she has grounded—a very different thing. The first form occurs before the grounding, the second after it.—ED., THE E.]

L.M.S. DIESELS

SIR,—I should like to make two comments on your editorial of March 28th with reference to the new L.M.S. diesels.

First, although these locomotives have been set alongside certain existing steam types in order to give a rough-and-ready idea of the kind of work on which they are to be employed, a word of caution is necessary against carrying the comparison too far. The basic principle of the two prime movers, maximum torque at maximum revolutions in the one case against maximum torque at minimum revolutions in the other, and the widely differing characteristics of the resulting transmissions, make it impossible for any diesel to correspond exactly in performance range to a steam locomotive.

The steam locomotive can sustain a "continuous rating" at any point within its tractive effort/speed curve, and so is ideally adaptable to mixed traffic working. In a diesel-electric, where dimensional and weight limitations control the size of the motors, continuous rating is usually only available over the higher speed end of the tractive effort/speed curve, and performance at high tractive effort and low speed is subject to a time limitation connected with permissible heating of the motors.

Such being the case, the proposed 1600 h.p. L.M.S. unit, for example, while able to attain the same continuous rating as a steam class "5" mixed-traffic engine above 35 m.p.h., is not able to run indefinitely at maximum tractive efforts below that speed. The result is that a survey is necessary of the specific routes over which the locomotive may be required to work, so as to ascertain the length of time it may be called upon to sustain given tractive efforts at given booked speeds. In this field, which is generally representative of freight working on heavy gradients, the performance of the locomotive will come out more nearly comparable to that of the class "4" 2–6–4 tank engine. Alternative gear ratios assist, of course, in lowering the speed beyond which continuous rating is available, but these are not ideally adaptable to true mixed-traffic working.

My second comment concerns the implication that the power/weight ratio of the L.M.S. diesels is behind the times.

I have no record of a modern well-tried American main line diesel which comes out at less than 153 lb of locomotive weight per engine h.p. The average appears to run more round 170 lb, and one of the most recent designs, namely, the Baldwin 3000 h.p. unit, exceeds 190 lb per h.p. The L.M.S. units will compare favourably with these figures, and so important is complete reliability in service that I feel that we should be slow in accepting weight reduction as an unqualified yardstick of progress in this field.

H. G. IVATT.

Derby, April 19th.

INTERNATIONAL CONGRESS OF ENGINEERING EDUCATION.—With the approval of the American Military Government in Germany, plans are now being made for an International Congress of Engineering Education to be held at Darmstadt from July 31st to August 9th next. Among matters which it is proposed the Congress should discuss are the ethical and cultural aspects of technology, the present state and trends of development in engineering education throughout the world, and the exchange of professional ideas. Further information concerning the Congress can be obtained from the Rector of the Technische Hochschule Darmstadt, Darmstadt, U.S. Zone, Germany.

Metallurgical Topics

Economy Steels in France

Soon after the liberation of France, in 1945, a conference was held with representatives of the Allied Expeditionary Force, in the course of which a report was made by Monsieur André Sourdillon* on the development of economy steels to replace the pre-war standard alloy steels.

Before the war a feature of French metallurgy was the production of a whole range of alloy steels, perhaps in some circumstances too rich in alloy elements but certainly possessing very remarkable characteristics. This favourable situation changed with dramatic suddenness after the Franco-German armistice. In addition to the failure of supply, the army of occupation requisitioned almost the whole of the stocks of alloy elements in the country, including the nickel coinage.

As in other countries, two steps were taken in face of the acute shortage of material: (1) Absolute prohibition of the use of high alloy steels, except for essential purposes, and (2) replacement of the alloy steels commonly used by new steels less rich in alloy additions, but, nevertheless, possessing useful properties. This policy was followed for four years in spite of all manner of difficulties, in particular the confiscation of laboratories and works, and the deportation of specialists. It was known that the low-alloy steels would have mechanical properties inferior to those of the standard pre-war steels, but it was essential to determine the best proportions of elements available and the best conditions of manufacture and treatment of the new steels. This work was aided by the results of previous German investigations having the same object, and by the desire on the part of the French to reserve for their own purposes as much of the high quality material as could be secured out of the little they possessed.

Availability of Alloy Elements

The successive replacements* of standard pre-war alloys were made with the relative effect of the different alloy elements in mind, but were mainly governed by their availability. The supply position was naturally controlled by the Germans. After 1941 there was no question of the use of nickel in constructional steels. Molybdenum was also on the way to disappearing; supplies from Morocco were cut off by the blockade, and from 1942 on its use was no longer allowed except for special purposes, *e.g.*, tool steels. Chromium, on the other hand, was produced in important amounts in the Balkans. This element could therefore be used fairly abundantly until 1943, and the position with regard both to constructional steels and to tool steels was further helped by the fact that ferro-vanadium was obtainable as a product of the German processes for the recovery of vanadium from slags. Later, supplies of chromium were reduced, and difficulties in maintaining satisfactory quality of alloy steel increased. Manganese rapidly became the fundamental alloy element in constructional steels. The demand for manganese was supposed, in 1942, to be amply covered by European production, but the supplies sent to France were derived from the Donetz basin, and a shortage followed the recovery of this district by the Russians in 1943.

Constructional Steels

The successive replacements of constructional steels for use in the hardened and tempered condition are shown in Table I. The reduction in nickel content was followed by reversion to the pre-war chromium-molybdenum steel (but with lower molybdenum) and this was replaced by chromium-manganese and, finally, by manganese-silicon steels.

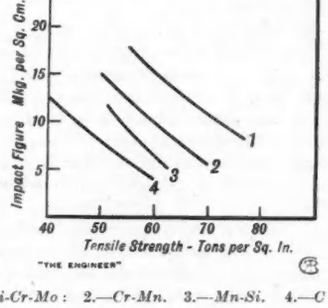
The alternative steels were the subject of extensive investigation to determine their behaviour both in laboratory tests and in service. The lower nickel in the nickel-chromium-molybdenum steel gave rise to no ill effects, and the use of steel of this composition is said to be likely to continue. The most marked characteristic of the substitute steels was their inferior hardenability, which restricted the section in which they could be employed satisfactorily. An attempt to increase strength by raising the carbon content gave rise to undue brittleness. Temper-brittleness, previously suppressed by molybdenum, appeared, to a greater or less degree, according to composition and to the dimensions which governed the rate of cooling after tempering, in steels which contained no molybdenum. As shown in the diagram (Fig. 1) the notched-bar impact value obtainable with a given tensile strength tended to be lower at each stage of substitution, and the use of some of these steels for pinions, which, though moderately stressed were subject to shock, had serious consequences. On the other hand, the chromium-manganese steels in particular showed improved fatigue limits and resistance to wear which made possible their use for highly stressed gears.

In susceptibility to grain growth at high temperatures and to deformation and cracking on quenching the substitute steels were much inferior to the pre-war high nickel steels, and they therefore required particular care in forging and heat treatment. Special methods, such as interrupted quenching, were employed to diminish these defects.

Table I.—*Principal Elements in French Constructional Steels For Use in the Hardened and Tempered Condition*

No.	Type	Date	Approximate Composition, Per cent						
			Ni	Mo.	Cr.	V.	Mn.	Si.	C.
1.	Nickel	Pre 1940	2 to 5	—	—	—	—	—	0·30
2.	Nickel-chromium-molybdenum	,, ,,	2·8	0·2	1·0	—	—	—	0·30
3.	,, ,, ,,	,, ,,	3·5	0·2	1·5	—	—	—	0·30
4.	Chromium-molybdenum	,, ,,	—	0·2	1·2	—	—	—	0·30
5.	Nickel-chromium-molybdenum	1940–41	1·3	0·2	1·5	0·05	0·8	—	0·30
6.	Chromium-molybdenum	1940–41	—	0·1	1·2	—	0·9	—	0·30
7.	Chromium-manganese-vanadium	1942–44	—	—	1·0	0·15	0·9	—	0·30
8.	Chromium-manganese	1942–44	—	—	0·7	—	1·2	—	0·35
9.	Manganese-silicon	1944–45	—	—	—	—	1·3	1·2	0·35

Steels, similar in composition to Nos. 1, 2, 4, 5, 6, 7 and 8, but with 0·1 to 0·15 per cent of Carbon were used for Case Hardening.



1.—*Ni-Cr-Mo*: 2.—*Cr-Mn.* 3.—*Mn-Si.* 4.—*C* Steel.

Fig. 1—*Impact Values (Mesnager) of Hardened and Tempered Steels (Sourdillon)*

Tool Steels

The most important alloy element in the pre-war high-speed tool steels was tungsten, the rapid disappearance of which enforced the use of molybdenum and vanadium. Table II shows the composition of three tool steels which, among the numerous compositions tried, may be said to have been standardised for war-time use, in comparison with French pre-war tool steels. Opinions based on cutting tests with these steels were very divergent; the first and richest type seems to be equivalent to the old 18 per cent tungsten steel and the last of the three to the 14 per cent tungsten steel. With refinements of pyrometric control, cyaniding after tempering and possibly sub-zero treatment to decompose residual austenite, it is possible that a steel of the 10 per cent tungsten type may be able to compete in future with the 18 per cent tungsten steel.

Future Possibilities

Though it be recognised that the substitute steels are of lower quality than the earlier ones, the question must arise in view of the need for future economies, as to whether it will be possible to manufacture from them machines and appliances giving equivalent service and reliability to those made from the more highly alloyed steels. To this question the French report replies in the affirmative, the opinion being based on the supposition that the intrinsic quality of the steels will be raised by improved steel-making technique.

Table II.—*Composition of Some French Tool Steels*

Date	Composition, per cent									
	W.		Cr.		Mo.		V.		Co.	
Pre-war	14	...	4	...	—	...	0·5	...	—	
,,	18	...	4	...	1·0	...	1·0	...	—	
,,	21	...	5	...	1·5	...	1·0	...	5 to 10	
,,	2	...	4	...	10·0	...	1·0	...	—	
1940–45	10	...	4	...	1·0	...	3·0	...	—	
,,	6	...	4	...	5·0	...	2·0	...	—	
,,	3	...	4	...	3·0	...	3·0	...	—	

At the same time the hope is expressed that more accurate knowledge of directional and localised stresses, gained by the methods of photo elasticity, by the indications of strain gauges, and by the use of adherent lacquers of high elastic modulus and low elongation, to reveal regions of stress concentration will give the means of designing with greater security and thus of employing steels having more modest characteristics than those used in the past.

Stress Corrosion of Manganese Bronze Castings

Manganese bronze, on account of its excellent resistance to sea-water corrosion, is frequently employed for underwater fittings in naval and marine equipment. Unfortunately, manganese bronze castings, if stressed above their yield strength in contact with sea water, are subject to stress corrosion. Such castings have therefore to be designed with a factor of safety calculated to maintain the stress at a value well below the yield strength of the part in service. Even so, the yield point may be exceeded by accidental or localised stresses which arise during service, and failure may ensue at stresses well below the ultimate tensile strength of the material.

Failures of this kind, which have occurred in the U.S. Navy, have been investigated by T. L. Sheehen and H. E. Dickerman*. It was significant that, out of twenty broken manganese

* A. Sourdillon: "Les Aciers de Remplacement," *Revue de Métallurgie*, Vol. 42, 1945, pages 295–304.

* *Journal* of the American Society of Naval Engineers, 1946, Vol. 58, pp. 586–598.

bronze castings, all the failures had occurred in those which had operated in sea water and not one failure had been reported from castings of similar design operated inboard. In each case the zinc and aluminium contents were sufficiently high to produce microstructures showing β solid solution only, and the cracks which had occurred were all intercrystalline.

The U.S. Navy Department Specification, to which the castings (which would be more accurately described as "high-tensile brasses") were supplied (49B 3e) laid down the following limits of percentage composition: copper, 55 to 60; lead, 0·40 (max.); aluminium, 1·50 (max.); manganese, 3·50 (max.); iron, 0·40 to 2·00; tin, 1·00 (max.); other elements, 0·20 (max. of each); zinc, remainder. Many castings were just within the 1·50 per cent limit of aluminium, others contained up to 2·0 per cent, and with zinc ranging upwards from 37 per cent, the structures were completely β solid solution.

Some investigation was carried out both on the material of the failures and on two specially cast alloys having an all-β structure and an α + β structure respectively (Nos. 8–11 and 20–24 in Table I). Specimens surrounded by a jacket containing sea water, changed twice weekly, were kept under continuous load in a testing machine. In order to expedite tests, other specimens were held in chromium-plated jigs while stress was applied in the testing machine, and the strain produced under load was maintained by screwing up spacer bolts, which were tightened until the load was transferred from the testing machine to the top and bottom plates of the jig, the pull of the test-piece being balanced by the compression of the spacer bolts. An extensometer was left attached to the test piece during the changeover to check the constancy of strain. Some relaxation of the load may have occurred under these conditions, but the indication of specimens held continuously in the testing machine was that creep was very slight.

TABLE I.—*Percentage Composition of some of the Alloys investigated (Sheehen and Dickerman)*

No.	Cu	Al	Fe	Mn	Zn
1—7	56·61	1·91	1·16	1·70	38·62
8—11	56·54	1·75	0·78	0·36	40·57
13	58·60	1·64	1·20	0·40	38·16
15	54·37	1·50	1·29	0·67	42·17
20—24	58·53	0·79	0·73	0·09	39·86

The procedure was to load the specimen to a stress below the yield point (taken as the load giving an extension of 0·01in in the 2in gauge length while under load), then to immerse in sea water for a certain time and, if no cracks appeared, to increase the load to a higher value, continue the immersion for a period and repeat the operation until failure occurred.

Table I shows the chemical composition of some of the castings used. A few typical examples are given in Table II to indicate the effects observed and the pronounced difference in sensitivity of the two structures to stress corrosion by sea water. No failure occurred below the yield strength. The β alloys were able to withstand (for times employed in the tests), on an average, loads exceeding their yield strength by 1594 lb per square inch, and the α + β alloys by 8625 lb per square inch (0·71 and 3·85 tons per square inch, respectively). The elongations on 2in at failure were, on the average, 1·9 for the β alloys and 8·4 for the α + β. The average period, under the stress-corrosion conditions employed, before failure occurred, was 4·31 days for the β alloy and 83·25 days for the α + β alloy.

The failures of the β-brasses occurred round the grain boundaries, while the failure of the α + β alloys was, at least in part, transcrystalline. Susceptibility to intercrystalline attack would thus appear to be related primarily to microstructure. In its influence on microstructure one part of aluminium is supposed to be roughly equivalent to six parts of zinc, while one of manganese is equivalent to 0·5 and one of iron to about 0·9 parts of zinc. Although the authors do not deal with the separate effect of the added elements on the tendency of the high tensile brasses to fail under condition of stress corrosion, an indication is thus given that it is most important in these alloys to preserve a proper balance between the aluminium content on the one hand and the iron and manganese on the other.

TABLE II.—*Typical Examples of the Effect of Immersion in Sea Water (Sheehen and Dickerman)*

Medium	Sea water			Atmosphere		
No.	Loads in lb per square inch Preliminary loading	Final load	Time	Yield Stress	Ultimate Stress	Elongation Per cent
1	—	—	—	39,750	85,750	16·5
5	37,500, 6 days	40,000	2 days	—	85,000	18·0
6	Up to 37,500, 45 days	40,000	3 days	—	—	1·0
8A	—	—	—	38,000	85,750	18·5
8	—	39,000	3 days	—	—	nil
9	—	39,000	6 days	—	—	2·0
10	—	40,000	4 days	—	—	1·0
11	—	40,000	12 days	—	—	4·0
13A	—	—	—	38,000	87,100	22·0
13	Up to 37,500, 14 days	40,000	2 hrs.	—	—	2·0
15A	—	—	—	28,250	88,000	27·5
15	—	30,000	*	—	—	nil
20	—	—	—	28,000	68,750	28·0
21	Up to 32,500, 80 days	35,000	16 days	—	—	11·0
22	Up to 32,500, 80 days	35,000	16 days	—	—	8·0
23	Up to 35,000, 38 days	37,500	28 days	—	—	6·5
24	Up to 35,000, 28 days 37,500, 8 days	39,000	8 days	—	—	8·0

*Broke overnight.

Poisson's Ratio for Large Strains

INVESTIGATORS at the U.S. Bureau of Standards* have applied a new technique involving the use of electrical strain gauges to the measurement of Poisson's Ratio of an aluminium alloy (24 S, copper 4·4 per cent, magnesium 1·5 per cent, manganese 0·5 per cent) in two conditions and several thicknesses, of a chromium-molybdenum steel and of two mild steels containing 0·22 and 0·25 per cent of carbon. Poisson's Ratio of the aluminium alloy was dependent on the direction of the axis of the test-piece in relation to the direction of rolling. Within the elastic range in sheet 0·032in thick it was 0·322 in specimens taken in the longitudinal direction, 0·320 in those taken transversely, and 0·332 in specimens cut at 45 deg. to the direction of rolling. When the elastic range was exceeded the value rose quickly to 0·36 and 0·38 at 0 and 90 deg., and to 0·44 at 45 deg., to the direction of rolling, a curious discontinuity being observed at about 2 per cent extension. In the mild steel, which was 1½in thick, the effect of direction was negligible. The value was 0·26 to 0·28, within the elastic range, rising steeply to 0·40 when the yield point was passed and then very slowly to 0·43 at 2 per cent extension. This is the type of result that would be expected on the assumption that the elastic change of volume ceases to increase (or at least increases only very slowly) after the yield point has been reached.

* A. H. Stang, H. Greenspan and S. B. Newman: "Journal of Research of the National Bureau of Standards," Vol. 37, October 1946, page 211.

Machinability

AN article on "Good and Bad Structures in Machining Steel," by Dr. Norman E. Woldman,* in *Materials and Methods*, may serve as a postscript to the very informative Conference on Machinability arranged by the Institution of Mechanical Engineers last year at least in one of its aspects. Dr. C. Sykes, in a brief but comprehensive paper read at the Conference, dealt with "Machinability and Structure of Ferrous Materials." Dr. Woldman's conclusions, illustrated by about thirty photomicrographs of steels in conditions showing different degrees of machinability, are on somewhat similar lines. They are consistent with the principle mentioned by Dr. Sykes that "for good machinability a combination of low hardness and low ductility is required," an unnatural combination which can be induced by certain additions or treatments but which is frequently inimical to the purpose for which the material is intended.

There is, however, as shown in Dr. Woldman's article, a close relationship between the machinability of a steel and the properties and structure of its micro-constituents.

Ferrite, though soft, is tough. It tends to tear away from the stock, leaving a rough surface. It adheres to the cutting tool, building up on the cutting edge and creating excessive frictional heat. The low-carbon steels are best machined in the normalised and then cold-drawn and stress-relieved condition. The harder the steel is made the better, since in its effect on machinability the loss of ductility outweighs the increase in hardness.

Lamellar pearlite is rigid. The tool cuts across the alternate plates of hard, brittle iron carbide and soft, ductile ferrite; but wear becomes considerable as the amount of pearlite increases. Hence in normalised steels ease of machining increases in general with increasing carbon content up to about 0·3 per cent and then decreases. The mild steels machine best, both in roughing and finishing, when they have a uniform structure of ferrite plus lamellar pearlite. (It might be added that in these steels also machinability is improved by a slight degree of cold work.)

In a spheroidised pearlite structure the hard particles of carbide set in a soft ferrite matrix are pushed aside without much wear on the tool, but the surfaces will tear and tend to be rough and ragged. Thus, in medium-carbon steels a spheroidised structure is best suited for rough machining, but a pearlitic structure is required for all finishing operations. When the carbon content is increased to eutectoid proportions and above, the lamellar structure, though still giving the better finish, develops more heat and necessitates more frequent regrinding of the cutting tools and therefore a spheroidised structure is required for all operations.

Dr. Woldman concludes with a warning against two structures to be avoided at all times, viz., banded structures and a structure of adjacent coarse and fine grains; though the condemnation of these may perhaps deserve some qualification.

Banding, associated with non-metallic incluclusions or phosphorus segregation, though it may be undesirable for various reasons, is not necessarily bad for machining. That depends upon the nature of the inclusions. Regular parallel banding has in some circumstances been found to be an advantage in drilling operations. The duplex structure of coarse and fine grains is probably only bad if there is an appreciable difference in hardness between the grains. A big difference in hardness between adjacent grains is not infrequent in air-cooled 1·5 per cent manganese or low-alloy steels, and the effect on the tool is ruinous.

A set of photomicrographs forming a graded classification of structures in relation to machinability can, if based on good evidence, be very helpful, provided that the limitations imposed on the structure of the material by its subsequent use are fully recognised and that the equally important factors of tool design and machine operation are not overlooked.

* *Materials and Methods*, Vol. 25, Feb. 1947, pp 80–86

THE ENGINEER

APRIL 25, 1947

Vol. CLXXXIII No. 4761

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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INSTITUTION AMALGAMATION

JUST over a year ago we reported that a postal ballot of the corporate members of the Institution of Mechanical Engineers had just been held to decide whether that Institution and the Institution of Automobile Engineers should amalgamate. The result of the ballot revealed that there was the necessary two-thirds majority in favour of the proposal, and, the members of the Institution of Automobile Engineers having already expressed approval, application was made jointly by the two chartered Institutions to the Privy Council for the necessary powers. As announced on page 359 of this issue, the authority was recently granted, and on April 13th amalgamation officially took place. Our congratulations are due to these two Institutions upon the taking of a step in very much the right direction. We believe that very rapidly the loyalties of the members of the two Institutions will be fused into a single loyalty to a greater and stronger Institution of Mechanical Engineers, whose prestige will be heightened by the activities of its new Automobile Division.

Many of those who remember the intimate atmosphere of the meetings of the Institution of Mechanical Engineers only twenty years or so ago, must inevitably regret the enlargement of the membership that must be a consequence of this amalgamation. Yet can it really be denied that such an enlargement is in tune with the times? For quite apart from the effect of the amalgamation and in spite of the imposition of more rigorous standards of qualification, the number of members has been growing at an accelerating pace for many years, and other institutions have experienced the same phenomenon. The truth, we fancy, is that in a world so largely dependent as ours upon the work of engineers and one in which governments, even if conservatively inclined, feel it necessary to consult, direct or advise all classes and all organisations in the community, it is becoming necessary for engineers to speak both at home and abroad more clearly and more in unison than in the past on matters that affect their technical and professional careers. The trend towards a greater unification is illustrated as much by the recent closer association of the Iron and Steel Institute with the Institute of Metals, by the coming amalgamation of the F.B.I. and the British Employers' Confederation, and by the continuous close consultations on many matters during the last few years of the Institutions of Civil, Mechanical and Electrical Engineers as by the amalgamation that took place on the 13th of this month between the "Mechanicals" and the "Automobiles." Moreover, the advantages of such closer accord, whether by amalgamation or by other means, are felt internally as well as in the external contacts of the societies involved. As engineering knowledge spreads its boundaries, it becomes less and less possible for even the finer minds to comprehend in anything approaching full detail more than a small part of the field. Indeed, it was no doubt that fact that lead originally, and still sometimes continues to lead, to the creation of specialist societies concerned only with some particular facet of engineering. Yet it is clearly desirable, no less for the benefit of engineers at large than for specialists themselves, that interchange of information should easily take place all about the field of engineering. Pump, compressor and turbine manufacturers, for instance, owe much to the researches of aircraft engineers. Automobile and machine tool designers have learnt a great deal from one another. Designers of all kinds are influenced by the discoveries of metallurgists. Civil engineers are even considering whether the theories of alternating electric currents may not prove useful for the study of tidal events. Such a list of examples could indefinitely be extended. But the existence of separate specialist institutions concerned only to discuss their own problems interposes a bar (if only through the mere cost of membership of several such societies) to the rapid interchange of knowledge. That barrier, we feel, is best broken when specialist bodies of high standing and prestige, such as the Institution of Automobile Engineers, associate themselves, either by amalgamation or in some other way, with their natural parent bodies covering a very much wider field. For by thus throwing open their meetings to engineers of all kinds within the parent body, they not only help to enrich their own counsels, but help, too, to spread the leaven of their own specialist discoveries and opinions over the whole of engineering.

We are, of course, well aware that such arguments will not find universal support amongst engineers. In the poll of the Mechanicals covering the recent amalgamation, for example, nearly one-third of the votes cast were cast against the proposal. But how far, we wonder, can that opposition be taken to represent a real objection to amalgamation in itself? How much of it arose, for instance, because members were asked to decide within a few short weeks upon a matter of such great importance to the Institution that it had been under discussion by the Institution Council for very many months? In fact, members were asked to decide about two points, both worthy of deep consideration; first, as to whether amalgamation in itself was desirable, and, secondly, as to whether the terms arranged were satisfactory. But to judge by the confused discussions that took place at meetings and in private, too little time was given for members to reach a conclusion upon the first point before they were asked to decide upon the second. More time might well, we think, have created greater unanimity. Since the Privy Council has signified its approval of the amalgamation, there can no longer remain any doubt, as seems to have existed in the minds of some of those who opposed the project, that in all its actions the Council of the Mechanicals was acting with perfect propriety and within the terms of the Institution Charter. Yet since we hope that further such amalgamations of related institutions will be proposed, we hope also that the experience of the Mechanicals will be carefully studied, to see what lessons may be learned from it, lest in the future votes be cast against which, had the lesson of the past been better understood, might well have been thrown upon the other side.

CAB-RANK POLICY

ON every cab-rank there is one vehicle better than the rest. It is kept more smartly, its enamel is brighter, its upholstery more comfortable, its engine runs more sweetly, and it rides better. One can tell that the owner-driver takes a pride in it, and, like his car, the cabby himself is well turned out. In his person he shows his self-respect and by his good manners and courtesy he shows his respect for his clients. Clearly, such a cab and such a driver invoke our patronage; they deserve to be selected in preference to the others, to be picked out and called for, even to be waited for. But cab-rank policy does not permit selection; it discountenances the survival of the fittest. Its rule is "First come, first served." No matter how ill-kept the cab and rough the cabby, the passenger must take the first on the rank. He is not allowed to encourage merit. On the cab-rank all are equal, good and bad alike.

There is nothing in the world that is not a balance between good and bad. Advantages have to be weighed against disadvantages, according to the conditions and circumstances of the age. Many of the things that we now look back upon appear to us bad. Yet we may be sure that they were the outcome of their day and were, for the time in which they prevailed, better on balance than alternatives which later minds and later methods, in their turn, made preferable. So it may be said that despite its manifest defects, the advantages of the cab-rank policy outweigh, at this time of the world, its defects. Otherwise it would cease to prevail;

it would not be found commonly existing in all kinds of affairs. We call loudly for promotion only by merit, but find such virtue impossible of complete attainment. The hopelessly bad may be weeded out, but the mediocre at least must be given an equal chance with the good. The best-organised and equipped firms do not get all the work. Trade associations see to that; sometimes by allocating orders, sometimes by fixing prices which give the poor firm a chance to compete. Under State planning such control of orders is likely to increase. If some area appears to be short of work, if full employment is not found there, then the purchaser will be instructed to place his order in that area. That is the State's method of pursuing the cab-rank policy. It may offer "jam and judicious advice" to the inefficient, but it will not permit it to be driven out of existence by the more efficient. In the works and factory, the policy has been common for many years, probably hundreds of years. One amongst the objections to bonus systems of paying wages is that they encourage the able and industrious workman to set up higher standards than his fellows wish or are able to attain. His success is frowned upon and he is informed that he must moderate his efforts, that he must tone them down to a point nearer the general level. That, no doubt, is one of the restrictive practices against which Ministers are beginning to argue. It is unlikely that argument will be of much avail. It is hard to prevail against a practice which is not openly avowed, but is applied *sub rosa* in subtle ways.

There is something that touches us all very humanly in the cab-rank policy. It is not only that we have a weakness for helping lame dogs over stiles, but also because we feel that those who labour under some inherent defect for which perhaps they should not be held responsible, ought not to be overborne by those blessed with higher qualities. It does seem unfair to most of us that a fine old firm that has done great things in its day and for its generation, but is hampered by conditions, should never have a chance to compete with modern rivals. Economically, we may harden our hearts and say "Let them go," but our natural sympathies lead us in the opposite direction. And it is the same in the shops. Even in America, that land of hard-headed progress, firms are proud of the old men still in their service. It is quite understandable that workpeople should resent a pace being set by a few which is beyond the capacity of the mass. So far, the cab-rank policy has our sympathy, but it loses every fragment of it when in the highest or lowest places it is used as cloak for gross incompetence or sheer laziness. It is good whilst, all the time, there is an upward tendency, whilst the encouragement it offers inspires the worst cabs to emulate the best; it is bad when it tends to bring down the best to the level of the mediocre.

South Wales Steel Industry Development

In our issue of March 7th, we gave some particulars of plans for the development of the steel sheet and tinplate industry in South Wales. These plans include the erection of a continuous hot strip mill at Margam, the construction of two cold reduction mills at Llangyfelach, and Trostre, as well as a third mill—the exact location of which is to be decided—for the production of extra wide sheets. In announcing these particulars, early in February, Mr. E. H. Lever, Chairman of Richard Thomas and Baldwins, Ltd., said that the scheme had been submitted to the Iron and Steel Board for approval and expressed the hope that a favourable decision might soon be forthcoming. In the House of Commons, on Monday last, the Minister of Supply, Mr. Wilmot, announced that the Government had accepted the Iron and Steel Board's recommendations for the construction by the companies concerned of the new continuous hot strip mill and ancillary plant at Margam. Further, the Government agreed with the Board as to the need for new cold reduction and finishing plants for tinplate and steel sheet. The precise location of these, the Minister said, was under consideration by the Government in the light of the Board's recommendations and the sociological factors involved, and he hoped to make a further statement about them shortly. The Minister added that the scheme would not be in full operation for about three years.

Institution Amalgamation

It was announced in the early part of 1946 that the Institution of Mechanical Engineers and the Institution of Automobile Engineers were considering an amalgamation and that the application for the necessary powers had been made to the Privy Council. It can now be announced that authority has been given by the Privy Council, and that the Appointed Day for the amalgamation was April 13, 1947. On that day the Institution of Mechanical Engineers, under the powers recently granted, created an Automobile Division to focus its activities with respect to automobile engineering, and also on that day an agreement between the two Institutions came into force whereby the corporate members of the Institution of Automobile Engineers became corporate members of the Institution of Mechanical Engineers in appropriate classes, and simultaneously were placed on the register of its Automobile Division as the first members on the register.

This step has been taken as the result of long and detailed deliberations by the Councils of both Institutions, followed by the necessary approach to the respective memberships. Throughout the stages of consideration, we are informed, certain fundamental principles were kept in mind. It was considered that automobile engineering is essentially mechanical engineering and that mechanical engineers should have their interests promoted by one powerful Institution; and that the technical education and practical training of engineering aspirants would be better fostered by an amalgamation of engineering institutions which would provide a recognised national qualification in place of a number of specialised sectional qualifications. It would follow that the student would enter the profession through one broad entrance and subsequently specialise. With these tangible advantages in view, the Councils of the two Institutions now look forward to welding the combined membership into one whole Institution, and thus securing the increased strength and fullness in professional life which can flow from truly amalgamated effort.

Under the provisions of the amalgamation, the Automobile Division of the Institution of Mechanical Engineers will enjoy a considerable degree of autonomous life—its affairs will be managed, under the general direction of the I. Mech. E. Council, by the Council of the Automobile Division elected by the corporate members of the Division. The Automobile Divisional Council will be responsible for the technical meetings of the Division, and its papers will be published in a separate section of the "Proceedings" of the I. Mech. E. Local Centres of the Automobile Division will be organised in the branches of the Institution. Since all meetings and activities of the I. Mech.E are naturally available to all members of the Institution, it will readily be appreciated that a broadening of the professional life will be effected by the amalgamation.

Corporate members of the Institution of Mechanical Engineers who are registered members of the Automobile Division, will be able to describe themselves as "Chartered Automobile Engineers." Subsequent to the amalgamation, additions to the Automobile Division will be made solely from those who are members of the Institution of Mechanical Engineers, and applications will be reviewed by the Automobile Divisional Council, which will make recommendations to the Council of the I. Mech. E. respecting those considered to have the necessary experience to qualify for registration.

University of Sheffield Staveley Laboratories

It is announced that the Staveley Coal and Iron Company, Ltd., near Chesterfield, has promised to give to the University of Sheffield, by the means of a seven-year covenant, the sum of £50,000 towards the cost of the new Department of Chemistry. The interests of the Staveley Company go far beyond the production of iron, and embrace large-scale chemical manufacture, including the production of caustic soda, chlorine, hydrochloric acid, chlorates, aniline, and a wide range of basic coal tar products. The directors take the view that the encouragement of free university research in all branches of scientific chemistry must, in the long run, benefit both the company and industry as a whole. While the detailed applications of such work cannot be foreseen, the history of the chemical industries has shown that the advancement of academic knowledge provides the essential basis of all really progressive industrial development. The provision of new chemistry buildings is one of the most urgent parts of the post-war plan of the University of Sheffield. The new department will be close to the present building of the University in Western Bank, and it has been designed for teaching and research in all the main branches of chemical science. Its eventual cost will exceed £400,000, and it will be large enough for all work in chemistry, when the University attains its projected number of 3000 full-time students in all faculties. In particular recognition of the Staveley Company's munificent gift the University has decided to name the research laboratories of the new chemistry building "The Staveley Laboratories."

BOOKS RECEIVED

Internal Combustion Engines. London: Odhams Press, Ltd., 24, Henrietta Street, Covent Garden, W.C.2. Price 9s. 6d.

Engineering Reorganisation. Second edition. By James J. Gillespie. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 12s. 6d.

Heating and Air Conditioning. Sixth edition. By J. R. Allen, J. H. Walker and J. W. James. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, Aldwych, W.C.2. Price 27s. 6d.

Fowler's Architects, Builders and Contractors Pocket Book. Fourth edition. Altrincham: The Scientific Publishing Company, 316, Manchester Road, West Timperley, Altrincham. Price 10s.

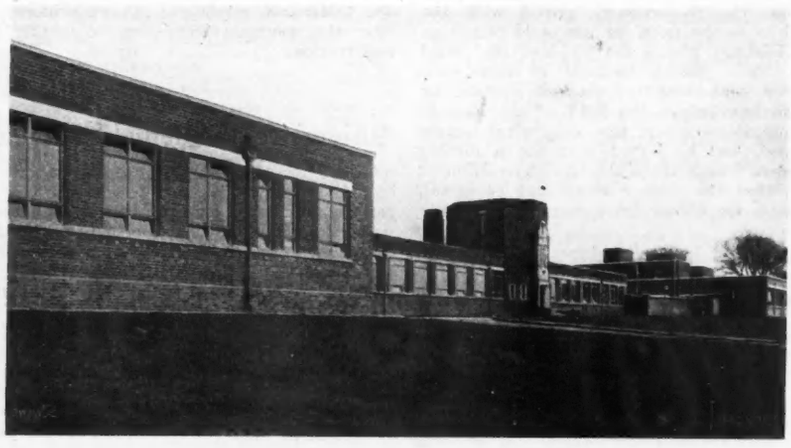
Metallurgy for Aircraft Engineers, Inspectors and Engineering Students. By R. A. Beaumont. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 25s.

The Law Relating to Building and Engineering Contracts. Fourth edition. By W. T. Creswell. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 25s.

Industrial Production Illustration. Second edition. By R. P. Hoelscher, C. H. Springer and R. F. Pohle. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, Aldwych, W.C.2. Price 22s. 6d.

Thornton Aero-Engine Research Laboratory

PROGRESS in aviation depends to a large extent on the development of aero engines and turbines, which in turn depends to a perhaps surprising degree on the knowledge we have of fuels and lubricants. To keep fuel and oil quality in step with the rapid wartime development in aero engines, an extensive and well-equipped centre, known as the Thornton Aero Engine Research Laboratory, was built during the war at Thornton-le-Moors, in Cheshire.



THORNTON AERO-ENGINE RESEARCH LABORATORY

One of the large petroleum companies, of which the identity was then, and still is, merged with the Petroleum Board, was responsible for the construction of the laboratory, which was begun in 1940 and completed in 1942. The importance of the scheme was appreciated by the Government and in the spring of 1942 it became the Ministry of Aircraft Production Fuel and Oil Research and Development Laboratory, in acceptance of an offer of the services of the laboratory for the duration of the war. During this period the work of the laboratory was in terms of research on fuels, oils and engines to improve performance and to solve operational problems in the Royal Air Force.

The laboratory was extended in 1943 and by 1945 a new wing, equipped for chemical and metallurgical work, was in use. Construction of a second wing, equipped mainly for work with engine test beds, was completed in July, 1945. The installation of engines and equipment in this wing has recently been finished. Thornton Laboratory has now been returned to the control of the company, which was responsible for building and operating it, and is at present directing its energies to civil aviation problems.

Equipment and Facilities

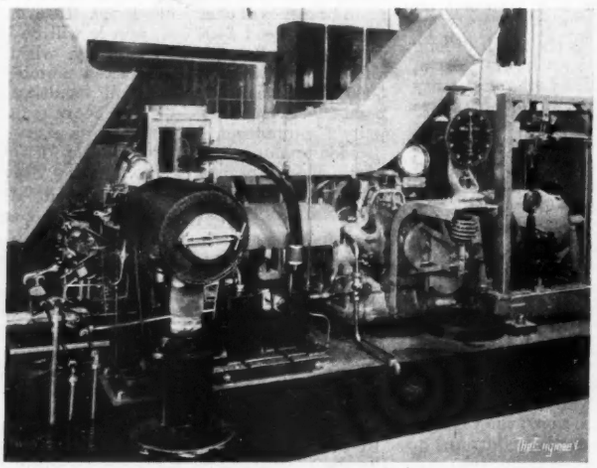
Thornton Aero Engine Laboratory has a staff of about 300, with Dr. C. G. Williams as director. To give this research and development team facilities second to none was the object when the laboratory was planned, and during the course of a recent visit we noted, in fact, some very fine new equipment and methods in use.

The work is carried out chiefly on single-cylinder engines, mounted on extensively equipped test beds in the engine test cells, and there is also, of course, a considerable amount of chemical and metallurgical work done in the laboratories. The main building houses a number of test cells and administrative offices, whilst the latest engine test wing houses test cells which embody numerous improvements suggested by work done in the first-built cells. Results of all tests are carefully reported and circulated to all interested parties. The work undertaken is frequently in close association with engine manufacturers and in association with the engine tests at other laboratories or in flight. Thus, during the war, much work was done on Merlin, Allison and Hercules engines. Other work arises from changes in oil refinery technique, necessitating a complete check on the characteristics and performance of the fuel or lubricant so produced.

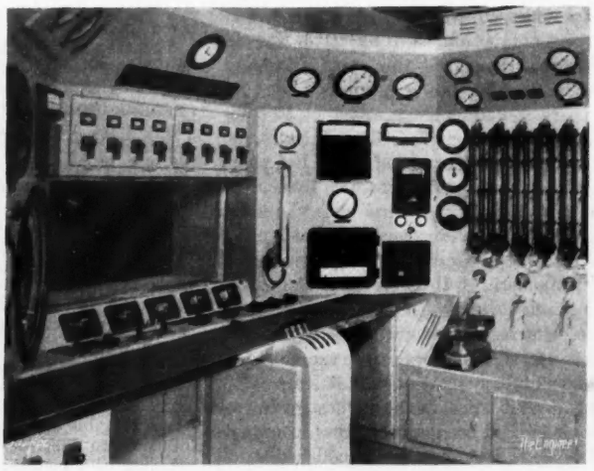
There are nine full-scale single-cylinder test cells, and five test rooms for smaller engines. A cold room is equipped to accommodate a complete main engine and to maintain it at minus 40 deg. Cent. There are two "rig" rooms. Laboratories include those equipped for analytical and metallurgical work, and for photographic and electronic methods of research. To back up the work of these sections there are, of course, machine and fitting shops and stores.

A general view of the building is reproduced herewith, whilst other engravings show a typical full-scale single-cylinder engine on test and the control room associated with it. As has already been mentioned, the new test wing incorporates many improvements. One of the more noticeable is the complete absence of vibration in the building and the very low level of noise. This result has been secured by extensive sound-proofing and by building each engine test bed as a massive, separate structure for each room, with independent foundations. By making the bed massive, its natural frequency is kept low, and by isolating it from the main structure of the building, vibration of the engine is not passed on. This lack of vibration is noticeable when stepping from the test cell to the adjoining control room; when the door between is closed it is easy to talk or work in quiet and vibration-free surroundings, and yet all the engine controls are immediately and conveniently to hand.

Equipment of the chemical and analytical laboratories cannot be described in full now; it must suffice to say that our tour of inspection showed conveniently arranged rooms, each of which is provided with services such as compressed air,



"HERCULES" SINGLE-CYLINDER ENGINE ON TEST BED

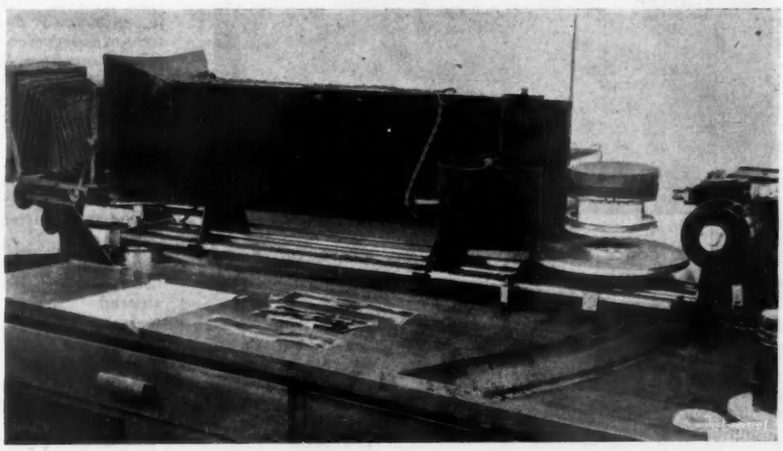


TEST CELL CONTROL ROOM AND PANEL

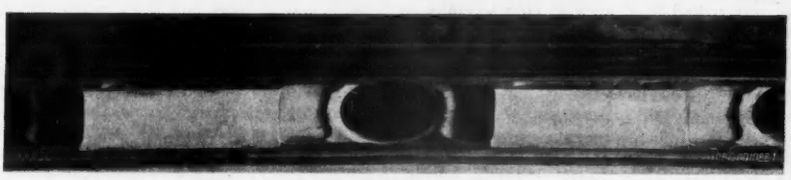
electricity at several voltages, and gas. We were interested to note the fine quality of work performed in the photographic department. Its equipment includes an Arditron lamp, permitting photographs to be taken with an exposure down to half-a-millionth of a second. This equipment is used for the photography of fuel sprays in gas turbine combustion studies. An accompanying engraving reproduces one of these photographs; it shows a low pressure (15 lb per square inch) spray issuing from the nozzle of a gas turbine combustion chamber.

"ARDITRON" PHOTOGRAPH OF FUEL SPRAY

A further item of interest was the equipment used for photographing pistons. In reporting engine tests it is important that uniform and complete records shall be available. The condition of piston rings and lands, and the amount of lacquer, scuffing or seizure marks present on pistons which have completed trials can be recorded only with difficulty, unless photographs are taken. But several photographs are required to record the complete periphery of a piston. The laboratory has overcome this difficulty by devising a standard method of photographing the whole of the periphery of a piston on one film. The apparatus is illustrated herewith. The piston is mounted on a vertical rotating spindle, driven through gearing by an electric motor. The spindle in turn is mounted on a framework, pivoted at the camera end and on a roller at the piston end. The camera itself is rigidly mounted on the bench and is a perfectly standard piece of equipment. On the pivoted frame are twin lamps for illuminating the object and a hood, terminating at the object end in a vertical slit. To take a photograph, a film or plate is put in the camera, the shutter opened, and the piston rotated through a full circle. This has the effect of causing the image on the film, as formed by beams passing through the vertical slit, to pass slowly across the film. The resulting photograph is reproduced herewith and represents the complete periphery of the upper part of the piston.



APPARATUS FOR PHOTOGRAPHING PISTON



RECORD OF PISTON PERIPHERY

WARTIME RESEARCHES

From 1941 to 1945 the programme of research related to the necessity for improving in military aircraft power and range, altitude performance, and reliability. It is notable that in connection with power improvement, late in 1943 it was indicated that if a fuel could be made available having a rich mixture performance, 20 per cent better than that of the current grade, certain engines could be up-rated to take advantage of this improved quality. Most of the initial experimental production blends were made up and tested at Thornton, and in the summer of 1944 the so called "150 Grade" was brought into use during the invasion of the Continent and was also used to produce the extra speed required for countering flying bombs.

Investigation of direct injection, using German engines and fuels, gave some interesting results. One of the important advantages of direct injection is superior weak mixture, anti-knock performance, in addition to the obvious benefit gained through a metered fuel supply to each cylinder producing a uniform mixture and quantity. Further investigation has now shown that the reason for the beneficial effect depends on cooling, due to evaporation of fuel within the combustion chamber, and on the fact that direct injection permits an increased valve overlap, which, in turn, leads to improved scavenging and internal cooling. These advantages were not fully appreciated five years ago.

Space is not, unfortunately, available for further reference to wartime researches, and no mention has yet been made of work on low volatility or "safety" fuels, the flight tests performed with members of the staff acting as observers, work on fuel vapour locks, work on valve and engine deposits or fundamental studies on oil oxidation. Ring-sticking, sludge formation, cold starting and gas turbine combustion studies all formed subjects of wartime study, some of which are still under investigation.

RESEARCH IN PROGRESS

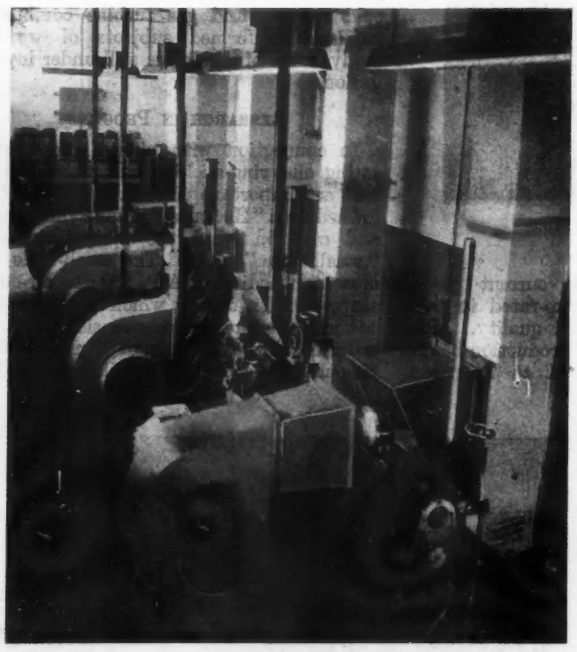
In connection with piston engine lubricating oils, ring-sticking and piston cleanliness are important criteria. Tests are performed on a "Hercules" single-cylinder unit, and also on what the laboratory terms "small-scale" units. The small-scale unit is a standardised J.A.P. 250 c.c. air-cooled single-cylinder engine, which has been found to reduce the cost of tests considerably. The criterion is the number of hours at which ring-sticking occurs. The oils examined are doped, the object being to develop successful additive-type oils. An accompanying engraving illustrates a batch of four such engines set up for oil tests. Dry sump lubrication is arranged for these units.

Another interesting research in progress is in connection with the protection of engine exhaust valves from the effects of high tetra-ethyl-lead concentration in the fuel. Valve burning, due to the effect of lead products on the stem and under the valve is found to be accentuated by unequal distribution of the lead products in the mixture. On multi-cylinder engines, one way of assuring perfect distribution would be to heat the charge to above 45 deg. Cent., say, by means of a mixture heater. Other methods are concerned with rendering the valve material resistant to the lead products. A nickel-aluminium-cobalt coating for the valve has been found effective, and other experimental coatings have been developed.

In gas turbine combustion studies, combustion efficiency is an important factor to evaluate. The fuel laboratory has developed improvements in the "vacuum" technique of gas analysis, in which each constituent is estimated directly by frac-

tional condensation and fractional combustion, to an accuracy of the order of 0·005 per cent. Where such high accuracy is not essential, a useful and rapid alternative method is in use. It estimates combustion efficiency by the measurement of the carbon dioxide content of the combustion products by passing them through an aqueous solution of sodium bicarbonate and following the change in hydrogen ion concentration.

Much research on turbine combustion problems is in progress. For some of this work a series of small quartz combustion tubes is used, in which the problems of the full-scale unit can be simulated, for example, combustion efficiency, carbon deposition, flame blow-out limits, flame-length, vibration and colour.



SMALL SCALE SINGLE-CYLINDER OIL TESTS UNITS

The Generation and Wholesale Distribution of Electricity*

By J. HACKING, M.I.E.E.†

TRACING the phenomenal growth in the public demand for electricity, Mr. Hacking showed how the load which was divided between mechanical power, heat, light, and various miscellaneous services, had increased approximately ninefold since 1920—an increase that was incomparably greater than that shown in the same period by any rival medium. Referring to the present shortage of generating plant and the necessity for load shedding, the lecturer showed that this situation was a direct result of Great Britain's unique war effort, involving, as it did, the complete cessation of all construction designed to meet purely peacetime development needs. Because the commissioning of new plant required some three or even four years from the inception of each scheme, the shortage of generating capacity must of necessity present a long-term problem. However, now that the Government had given overriding priority to the construction of new plant, some alleviation of the shortage could be hoped for by 1950. With the help of daily load curves, the lecturer showed how the generating stations were governed operationally by the incidence of maximum demand.

Forecasting future development of the electrical load in Great Britain, it was estimated that by 1960 an additional generating capacity of some 17,000,000 kW would be required, allowing for obsolescence in the plant that was at present available and in use. In the greater London area the anticipated growth of load would exceed the thermal plant extensions that could be envisaged in that area; the estimated deficiency would amount to about half a million kilowatts by 1960 and a corresponding amount of electrical energy would have to be imported.

Mr. Hacking showed some interesting slides to illustrate the different qualities of coal that were required to meet the particular needs of various classes of consumers—the railways, the gas and electricity supply industries, industry generally, and the domestic user. In passing, the lecturer demonstrated that in Great Britain it was generally cheaper to transport coal to power stations sited near the load centres, where ample cooling water was available than to place the power stations near the coalfields and to transmit the electrical energy to the load centres.

Discussing alternative prime movers to coal, Mr. Hacking showed that tidal power from schemes such as the proposed Severn barrage suffered from the grave disadvantage that they could not take their share of the peak load which recurred at the same hours daily. Water power in this country was limited and, even when fully developed, could not supply more than about 10 per cent of the total load that could be anticipated within the next ten or fifteen years. Coal was still our main source of energy and in our effort to make better use of available supplies, increasing attention was being devoted to district heating and the heat pump. The D.S.I.R. was examining the possibilities of district heating, but it was probable that its successful application would depend to some extent upon the intangible factor of public preference. The heat pump, making use of the low-grade heat of river water, had been applied commercially in Switzerland and experimentally in Norwich. Extended application of the heat pump was contingent partly upon a reduction in the capital cost of the installation.

There remained the gas turbine and nuclear energy as possible alternatives to coal for the generation of electricity. The gas turbine in units of 15,000 kW and upwards had a definite part to play, particularly in handling peak loads and installations in this country were now projected. Disclaiming any first-hand knowledge of the possibilities of nuclear fission, as applied to static power plants, the lecturer concluded by examining published information from American sources. In the light of existing knowledge, nuclear energy appeared to have little advantage over coal from the standpoint of cost, and commercial development on a practical scale in this country was unlikely within the next ten years.

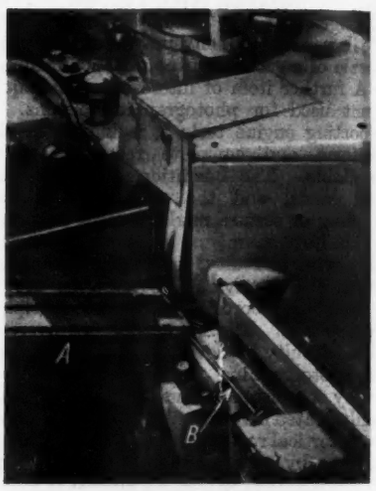
* Résumé I.E.E. Faraday Lecture. Central Hall, Westminster, April 21, 1947.

† Chief Engineer, Central Electricity Board.

Automatic Centreless Form Grinding

Particulars have been received from Arthur Scrivener, Ltd., of Tyburn Road, Birmingham, of an interesting example of fully automatic centreless grinding on one of the firm's controlled cycle machines. In these machines the use of a hydraulic slide replaces the hand-operated plunge-grinding method. The operator only keeps a magazine charged with workpieces, and the whole grinding cycle is performed automatically.

The detail photograph which we reproduce shows the actuating units of a controlled-cycle machine, designed to grind automatically formed pieces 0·140in diameter by 3in long, with stock removed varying from 0·005in to 0·010in, at a rate of 600 pieces an hour. The magazine A consists of a sloping chute on to which the components are loaded and descend by gravity to a point where they are ready to be pushed on to the workplate set between the grinding wheels. As the wheels open their movement advances a pusher, which, in turn, actuates an override arm. This arm, through an intermediate counterweighted shaft, advances the rod B to push the bottom component from the magazine on to the workplate between the wheels. The advancing component ejects the previously finish-ground piece and is halted by a stop which is interposed at the correct point. The controlled cycle slide then advances the control wheel and component up to the grinding wheel, against which it is held until the required amount of stock has been removed. The slide on its return stroke opens the wheels and the cycle is repeated.



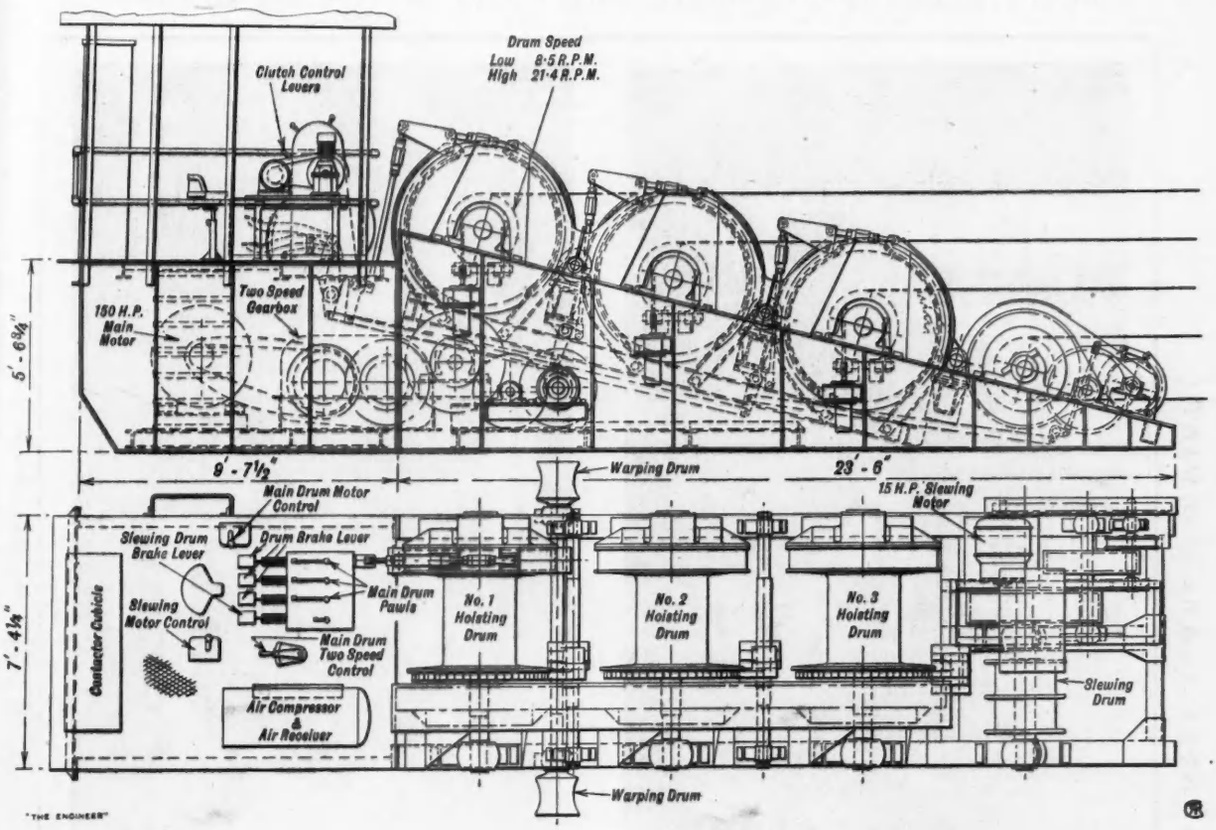
MAGAZINE AND PUSH ROD

The ejection of the finished component by the incoming piece and the introduction of the locating work stop calls for very precise timing to maintain the high-speed cycle. This timing is so arranged that, as the finished component is pushed along the workplate to fall into the discharge chute, the locating stop comes into position at the precise moment it starts to fall. The operation of the cycle only allows 1¼ seconds for the opening of the wheels, the ejection of the ground work, the advance of the new piece, and the interposition of the locating stop.

ALUMINIUM SCRAP IMPORTS.—The Minister of Supply announces that, with the agreement of the President of the Board of Trade, imports of aluminium scrap and aluminium alloy scrap are now allowed. Imports are subject to individual licensing and applications should be submitted in the usual manner to the Import Licensing Department, Board of Trade, 189, Regent Street, London, W.1.

GENERAL ARRANGEMENT OF 150 H.P. THREE-DRUM TRANSPORTABLE HOIST

SHEEPBRIDGE COAL AND IRON COMPANY, LTD., CHESTERFIELD, DESIGNERS AND BUILDERS



A 150 H.P. Transportable Hoist

TWO 150 h.p. three-drum, two-speed transportable hoists incorporating slewing gear and warping drums have been designed and built by the Sheepbridge Coal and Iron Company, Ltd., of Chesterfield, to meet the requirements of the Anglo Iranian Oil Company, Ltd., for service in the oil fields at Abadan in Persia. These machines, the second of which we recently had an opportunity of inspecting before despatch, are of particular interest, as they are claimed to be the first of their kind built in this country, and are thought to be the largest ever constructed. Each machine is designed to exert a line pull of 31,500 lb on two drums, simultaneously, at a speed of 60ft per minute, or a pull of 20,000 lb on a single rope, at a speed of 150ft per minute. Each of the three drums takes some 2500ft of rope and has a rope speed of 60ft per minute in low gear and 150ft per minute in high gear.

The hoists are to be used in conjunction with derricks and other lifting gear for the erection of refinery equipment such as fractionating towers and columns of various types up to 150ft in height and 225 tons in weight. Where this height is exceeded, the derricks will be raised to the main structure and the hoists will remain at ground level. Each hoist will work with a single boom derrick or a pair of masts, using ⅞in or 1in diameter wire rope. For the heaviest loads two masts will be used with two sets of sheave blocks, each having twenty-two parts. Notwithstanding the fact that the hoists weigh some 40 tons each, the nature of the work makes it necessary for them to be transportable without dismantling, in order that they can be moved from site to site in accordance with the erection programme. For this reason they will not be set on prepared foundations in service, but will be placed on the ground and anchored at the rear by means of chains to "dead men." These "dead men" will consist of 12in diameter pipes sunk horizontally about 5ft below ground level. Another restricting factor in design was that the machines had preferably to be kept within the loading gauge of the refinery railway system in order that they should be movable from one position to another on rail trucks. Low-loading trailers will be used as an alternative means of transport when necessary.

As the hoists will never be laid upon prepared foundations in service, particular care was called for in the design and construction of the main frames, in order that they should remain rigid and in true alignment when the machines are placed on uneven ground.

For convenience of shipment and in case at any time it might be desired to reduce the weight or size to be handled when moving a hoist, the main frame is built in two sections. The front section carries the three main drums, the warping drums and the slewing gear, together with their gearing, clutches, brakes, pawls and the motor for the slewing gear. The rear section comprises the operator's platform, on which are situated the control station, the air-compressor for operating the main clutches, the controllers for the hoisting and slewing motions, and the contactor cubicle for the main 150 h.p. slip-ring motor. Underneath this platform are housed the main motor, gear-box, "thrustor," brake and the resistance boxes for the two motors.

The general layout of one of the hoists can be seen in the drawing we reproduce above and the engravings on page 364.

The hoist frame, which is of all-welded steel construction, is well braced by heavy cross-members to form a rigid bed-plate for the drums and their driving gear. To ensure true alignment in assembly on site, the adjoining faces of the front and rear sections of the main frame are accurately machined, and they are positioned by means of pins, prior to being fastened together by fitted bolts. A series of light removable panels in the side plates of the frames give ready access for purposes of inspection to the electrical and mechanical equipment within. The continuous nature of the side plates and panels forms an outer dust shield for the chain drives, gears and bearings situated underneath the drums and control platform. In addition, the chain drive and gear-box are totally enclosed, and an oil and dust-tight casing covers the transmission gears. The front section of the machine weighs some 28 tons and to facilitate its movement by cranes, lifting beams can be inserted through three square-section tubular cross members which are set at appropriate intervals across the frame.

The 150 h.p., 980 r.p.m. main motor is adjustably mounted on the heavy steel girders which form the base of the structure supporting the elevated control platform. It drives the hoisting drums through a chain-belt and a two-speed gear-box, illustrated in Fig. 3, on page 364, which incorporates a claw clutch for selecting high or low hoisting speeds. From the gear-box power is transmitted to the spur wheel of the first hoisting drum through an idler gear. A large brake drum is fitted on the main driven shaft of the gear-box, and this brake, which is operated by a 250 lb "Thrustor," has sufficient power to stop and hold the hoisting drums under load. It works in conjunction with the control gear of the main motor and is independent of the braking system fitted to each drum. The first drum spur wheel drives the wheels of the succeeding drums through intermediate idler pinions. All of the gear shafts and pinions are mounted on roller bearings.

The mechanism of the hoisting drums, each of which is identical in design, can be seen from the drawing reproduced in Fig. 5. The drums are not fixed to the drum shafts, but are freely mounted on roller bearings on

150 H.P. THREE-DRUM TRANSPORTABLE HOIST

FIG. 1—HOIST WITH CANOPY REMOVED

FIG. 2—OPERATOR'S PLATFORM

FIG. 3—MAIN DRIVE GEAR-BOX

FIG. 4—SLEWING DRUM MECHANISM

the shafts, and driven through epicyclic gearing. Power is transmitted from the spur wheel to the drum shaft through the double toggle friction clutch of the makers' own design, illustrated in Fig. 6. This clutch is particularly effective in operation, combining a smooth pick-up of drive with a rigid locking action when fully engaged. It is operated by a single-acting compressed air cylinder, the piston of which is spring-loaded to withdraw and disengage the clutch, when the air pressure is released. On air being admitted into the cylinder, upward movement of the piston rod actuates a crank arm to force a sliding sleeve on the main shaft inwards towards the spur wheel. Coupled to this sleeve are two toggles, each of which reacts on a second pair of toggle levers to force two heavy friction shoes outwards into contact with a large friction drum on the side of the spur wheel. The bodies of the friction shoes are slideably connected by a pair of heavy keys to a cast steel driver fastened on the main drum shaft. The length of the inner pair of toggles is quickly and easily adjusted by a screw and a locking nut to set the friction shoe working clearance and take up any wear in service.

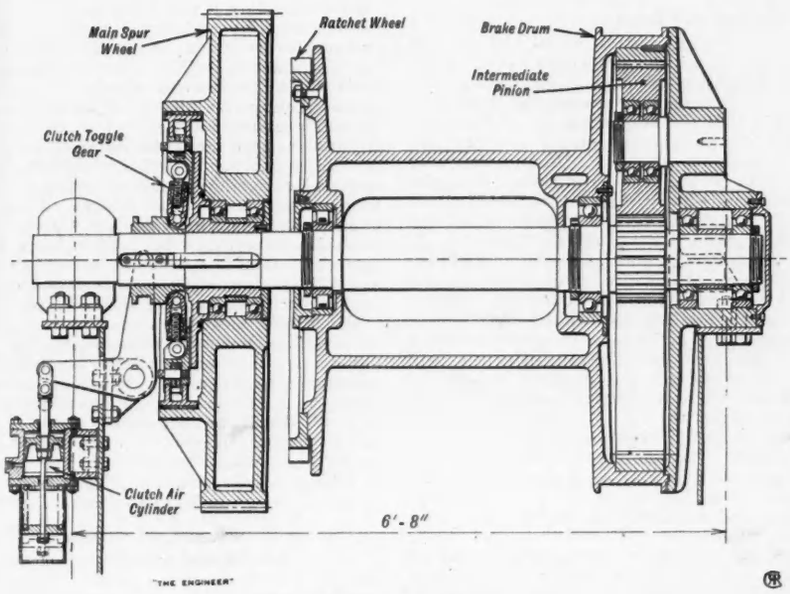


FIG. 5—HOIST DRUM MECHANISM

From the opposite end of the main shaft, drive is transmitted to the hoisting drum through a pair of planet wheels mounted between a pinion cut in the shaft and an internal gear ring fixed to the inner circumference of the drum brake flange. As can be seen from the drawing, these planet wheels are mounted on the drum end member, which also forms the main side bracket and pedestal for the drum shaft.

The drums are designed to hold up to 2800ft of 1in diameter rope in not more than ten layers. Bolted to each drum flange adjoining the clutch is a large cast steel ratchet wheel. Working in conjunction with the ratchet is a heavy steel pawl, operated from the control platform by hand lever through Hans Renold "push-pull" remote control chain operating gear.

Powerful brakes of the caliper type fitted to each drum are operated through a series of levers, the first of which is a toggle lever situated at the brake post. Means of rapid brake adjustment are provided and the brake lining is bolted in quickly renewable sections to the shoes.

The two warping drums, situated on either side of the hoist, are keyed to the ends of a common driving shaft mounted in ball bearing pedestals within the main frame. This shaft is driven through a dog clutch and two sets of spur gears from the idler wheel shaft of the main drive. When driven through the high speed side of the main gear-box the warping drums have a rope speed of 90ft per minute.

The slewing drum assembly at the front of the machine is illustrated in Fig. 4. It is driven by a separate 15 h.p. motor designed to give a rope speed of 30ft per minute with motor controlled creeping speed. As can be seen, the drum has a central rib cast round its circumference. In operation one end of a slewing rope is taken from over one side of the drum to the bull wheel on a derrick, where it is used for forward pulling, and the opposite end of the rope is returned to pass under the other side of the drum for reverse pulling. As each end of the rope has its own section of drum it is able to coil in a satisfactory manner. The drum shaft is driven by the motor through a chain belt and double reduction gears, all of which are totally enclosed. The drum shaft is mounted on angular pedestals, having plain, renewable gunmetal bearings, whilst all the other shafts run in ball bearings. A brake drum on the first motion shaft of the transmission gear is fitted with a band-type brake operated through links from the main control platform.

Special attention has been given to the lubrication and dust sealing arrangements throughout the hoists, as not only will they be exposed to desert dust storms but also have to work in the open air in summer shade temperatures of up to 125 deg. Grouped nipple grease gun lubrication has been widely used, and where possible the pipes leading from the nipples to the appropriate bearings have been run inside the main framework, where they are least exposed.

Particular attention has not only been given to the design of the control gear of the hoists, but also to the arrangement of the elevated control platform at the rear of the drums. From his seat behind the main control panel the operator has a clear view forwards and on both sides. All of the necessary levers are conveniently to hand and their operation entails but little, if any, manual effort. The disposition of the control gear can be seen in the general arrangement drawing and the photograph reproduced in Fig. 2. At the top of the control panel are four short levers, three of which operate the hoisting drum ratchet pawls, the fourth being used when it is required to set the warping drum in or out of gear. Projecting from the front of the panel at waist height are three more levers which actuate the single acting air valves operating the hoisting drum clutch gear. Below these levers are the pedals used for applying the brakes of the hoisting and slewing drums. Each of these pedals has a toe-release ratchet lock. The speed control box for the main hoist motor is at the drivers' left hand, and is operated by moving a handle over a notched quadrant. A similar control box on the right of the driver is used to operate the slewing gear motor. Selection of high or low drum hoisting speed is effected by movement of a short lever keyed to a shaft which extends downwards to the dog clutch in the main gear-box below.

At the side of the platform is an air compressor for the clutch operating gear, driven by a 2 h.p. motor. This compressor is automatic in operation and is designed for a working pressure of 110 lb per square inch, with a capacity of 4·9 cubic feet of air per minute. At the rear of the platform is the main contactor cabinet, which is fabricated from heavy gauge sheet steel. A canopy, having a double roof of corrugated sheet steel and timber, with an air space between, covering the whole of the control platform, is supported on a removable light steel framework bolted to the sides.

The normal method of operating the hoisting motion is to engage the air-operated clutch on the drum or drums required, and then to operate them through the main motor control. It is also possible, should occasion require it, to set the gears in motion and pick up the full load on the clutch. Lowering speed is controlled by the motor or, alternatively, by means of the brakes. Prior to despatching the hoists, the brakes were subjected to very severe tests by the makers. For the tests a weight of 7 tons was hoisted at the end of a 1in rope wound directly round each drum in turn. The weight was then allowed to fall freely through a distance of 8ft or 10ft before the brake was applied. The load was arrested in less than 2ft.

During our visit we were able to see the second hoist undergoing some of its tests and the ease with which the various controls worked was particularly noticeable, notwithstanding the size of the machine and the heavy duty it has to perform. To demonstrate the lightness and effectiveness of the brakes, we were shown how a load of 7 tons could be lowered under complete control, whilst the brake pedals were operated by a reasonably light hand pressure alone, even at the end of a fairly long free drop.

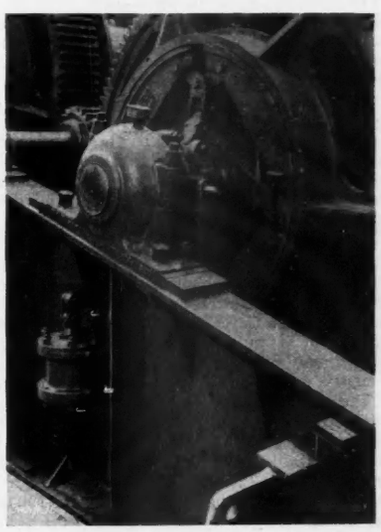


FIG. 6—HOISTING DRUM CLUTCH

BRITISH RAILWAY STAFF.—The Railways (Staff) Return prepared by the Ministry of Transport shows that the staff employed by the British railway companies and on the railway section of the L.P.T.B. numbered 652,253 on March 9, 1946, compared with 622,369 on March 10, 1945. The adult male staff on March 9, 1946, numbered 546,859, and the average earnings, in the week ended March 9, 1946, of men in the wages grades, were £6 1s. 6d., compared with £5 16s. 10d. in the week ended March 10, 1945.

Industrial and Labour Notes

The A.E.U. and Women's Pay

A resolution was passed at the Women's Conference of the Amalgamated Engineering Union at Bournemouth, on Tuesday last, asking the A.E.U. Executive to reaffirm its support for equal pay, and urging its implementation in Government Departments.

Mr. J. Tanner, President of the A.E.U., speaking at the conference, suggested that the 50 per cent reduction since 1943 in the number of women employed in the engineering industries could be accounted for by low wages and lack of day nurseries. The A.E.U., he said, stood by the rate for the job, and the T.U.C. had expressed its intention to approach the Prime Minister on the subject of equal pay. If the Government was not prepared to bring it into effect, Mr. Tanner continued, private employers could not be expected to do so without a struggle. Women constituted more than one-fifth of the total forces of the engineering industries, and the fact that they were receiving low wages was having an adverse effect upon production.

Britain's Overseas Commercial Policy

A statement regarding responsibility for Britain's overseas commercial policy, published recently in *The Board of Trade Journal*, explains that the formation of commercial policy and the conduct of trade negotiations with other Governments are primarily the responsibility of the Commercial Relations and Treaties Department of the Board of Trade. In addition to sections dealing with general matters, this Department has a number of officers who devote their time to particular countries or groups of countries. They keep in close touch with the relevant geographical and economic departments of the Foreign Office and also with the Treasury.

Furthermore, there is the Export Promotion Department of the Board of Trade, which concentrates mainly on the urgent need to expand United Kingdom exports. It maintains contact with individual traders at home and overseas who are engaged in the actual work of export, rather than with other Government Departments. In addition to these activities, however, it is responsible for providing the policy-making departments with the economic commercial and in many cases financial data on which policy decisions can be based.

Britain's Economic Situation

At a press conference in London on Friday last, the President of the Board of Trade, Sir Stafford Cripps, gave some particulars of a publicity campaign which the Government is organising in order to impress upon the people of this country the basic facts of the present economic situation. Posters, press advertising, factory talks, display sets, wall charts, and films, will all be utilised in what Sir Stafford described as "The Battle for Output." The cost of the campaign is estimated to be at the rate of between £300,000 and £400,000 a year.

At the beginning of his address to the press conference, Sir Stafford said that he had had useful talks both with the Federation of British Industries and the Trades Union Congress regarding their comments on the Economic Survey. There was general agreement on the steps which it was necessary to take, and there would be further meetings at various levels as matters developed.

Later on, Sir Stafford made some reference to coal output and said that the average weekly production in March was 3,844,000 tons, an increase of 70,000 tons on the February average. Coal output showed a reduction, however, in the first two weeks of April on account of the Easter holiday. The number of wage-earners on colliery books at the end of the first week of April was 708,000, an indication that progress in recruitment to the mines was being maintained. Sir Stafford also quoted various production figures which reflected the effects of the recent electricity crisis. The provisional figure for the value of March exports was, he said, £82,600,000, and he thought that reduced export figures must be expected for some months to come.

A final point made by Sir Stafford was the importance of salvage. He urged that there should be no waste of anything, especially where coal had been used in its manufacture, and was required for its replacement.

Anglo-Soviet Trade

Another matter mentioned by Sir Stafford Cripps at his press conference was the present position of Anglo-Soviet trade. He said that a temporary commercial agreement made in 1934 was still in force, and that prior to the war machinery represented about half our exports to Russia. During the war, trade between the United Kingdom and Russia, apart from military material, provided under mutual aid, had been confined mainly to civilian goods. Payment for these goods was 40 per cent in gold, platinum and dollars, and 60 per cent out of a credit of £50,000,000 at 2½ per cent. Imports from Russia during the war, Sir Stafford said, had been negligible.

Despite the limited size of pre-war trade, Sir Stafford continued, there ought to be a good market in Russia for British exports of machinery and industrial equipment, and Russia ought to be a potential non-dollar source of many important materials which we needed. The Secretary for Overseas Trade had gone to Russia to see if the flow of trade in both directions could be expanded. Sir Stafford added that our imports from the Soviet Union in 1946 totalled just under £5,000,000, and that our exports amounted to just over £9,000,000, of which more than half was for machinery. It was hoped to increase those figures very considerably.

More Comment on the Economic Survey

A few weeks ago, statements on the Government's Economic Survey for 1947 were issued by the Federation of British Industries and the Trades Union Congress, both of them containing suggestions for the solution of the major problems with which this country is at present confronted. Some more comments on this matter, and suggestions in many ways similar, have been made in the last week in a memorandum prepared by the Association of British Chambers of Commerce.

This memorandum opens with some remarks on the intention of the Government to set up a general planning staff, and points out that responsibility for the amendment, curtailment or adoption of the plan to be prepared is to rest with the Government. It is clear from this procedure, the memorandum continues, that, once more, Ministers and their departmental advisers in the Civil Service must call in and rely upon business experts for advice. The Association of British Chambers of Commerce affirms its readiness to assist the Government in the search for solutions of the serious problems facing the country, and has set out, in fourteen points, a suggested two-years' emergency policy.

The suggestions include the following: the consideration of nationalisation schemes not yet enacted should be deferred until more normal times are regained; immediate steps should be taken to assist in increasing coal and steel production, electric power station capacity, railway locomotives, wagons and transport facilities generally, and farming equipment; where the immediate needs of production can thereby be more efficiently met, encouragement should be given to an expanded importation of machine tool equipment, so long as this is unobtainable from home sources; the coal target should be raised to at least 220,000,000 tons and endeavours made to purchase 10,000,000 to 15,000,000 tons of coal from overseas for delivery over the next six months; unremitting attention should be given to maximum home food production and to providing assistance to the agricultural industry; immediate attention should be given to abolishing controls and licences no longer essential, and to reducing the swollen staffs of certain Government departments, while as soon as possible some Ministries should be abolished and others combined; the output from industries working a five-day week, and production costs, should be carefully watched; the policy governing wage rates should be reviewed by trade unions and employers under the overall guidance of the Government, with a view to assuring a basic wage but leaving ample rewards for increased output on the one hand and sanctions for bad work and idleness on the other; non-essential imports should be restricted or eliminated; the policy of bulk buying should be re-examined forthwith, and wherever possible terminated, leaving purchasing to expert organisations and individuals with years of practical experience in world commodity markets; direct taxation should be lowered and indirect increased; overtime earnings of workers should be taxed at reduced rates.

Finally, the memorandum suggests that the Government should indicate broadly but definitely the direction industry should take in meeting both home demands and overseas needs, and the priority countries to which exports should be expanded, regard being had to currency needs. Industry should then be left responsible for producing the goods, and be given Government priority assistance in obtaining materials in short supply.

Works Councils and Committees

The Industrial Welfare Society has recently published, at 2s., a new edition of a booklet entitled "Works Councils and Committees," in which are made some practical suggestions as to the functions, composition and procedure of such Councils. The material in the booklet is based on the practical experience of a large number of firms which contributed to a survey carried out by the Society, but no attempt has been made to lay down rigid methods of organisation. The aim is to show the various types of machinery which have proved successful in different industries.

The Government, trades unions and employers have been urging lately an increase in numbers and an extension in the scope of works councils and joint production committees as a vital means of promoting co-operation. The Industrial Welfare Society feels, however, that ignorance of the practical working of these committees has deterred many employers from establishing them. The booklet, it is suggested, should help to overcome this hesitation, since it sets out in simple form the essential functions of a works council and its relationship to the unions and supervisory staff.

The United States Steel Corporation

In a statement accompanying the annual report of the United States Steel Corporation, the chairman, Mr. Irving S. Olds, says that, throughout 1946, the American steel industry was faced with an enormous pent-up demand for steel products, desired by customers for delivery at such an early date as to be beyond the capacity of the industry to meet. The situation was, moreover, seriously aggravated by the disastrous steel and coal strikes during the year, resulting in the loss of more than one-fifth of the scheduled steel production for 1946. In view of the steel shortage, Mr. Olds continues, the Corporation adopted a policy of allocating its steel production in such a way that all customers would be treated on the same basis, with the result that all customers received less steel than the quantity they desired. Nevertheless, the Corporation's production of 21,300,000 tons of steel ingots and castings in 1946 has been exceeded in only six prior peacetime years.

French Engineering News

(From our French Correspondent)

PARIS, April 18th

France has recently published an interesting account of her industrial efforts in Tunisia. Although the country is poor in raw materials and power resources, official encouragement has created several factories. The manufacture of oxygen in considerable quantity is in progress by a concern known as "Air Liquide," which also has a compressed air plant near Tunis. Its equipment was destroyed in 1943, but the plant is now working again. Supply has increased constantly, the present figure being double that of 1942, which itself showed an increase of 50 per cent over 1936 figures. Installations for welding in Tunis now number 3000, and several farms have installed their own in order to repair agricultural machinery on the spot. Sole fuel in Tunisia is lignite, and in 1945 about 300,000 tons of coal were also consumed, but at the moment imports are irregular and sparse. The briquette factory at Bizerta, which once had a capacity of 300 tons a day, was destroyed by the Germans. It has now been reconstructed and is producing 200 tons a day. Three lead foundries exist in Tunisia, the Penarroya foundry, with a capacity of 24,000 tons a year; the Djebet Hallouf, with 5000 tons a year, and the Bizerta foundry, with considerably smaller output. Lead and zinc are also treated to produce oxides, used in paint, while lead is also made into pipe and sheet. Three small iron foundries also exist, and one important forge. Other industries of importance in Tunisia are fertilisers, soap and oil, glassware, construction materials, textiles, wood, and leather.

* * *

The work of the Modernisation Commission for Building and Public Works was recently described by its President, Monsieur Arrachard. The Commission was divided into five sub-commissions, which studied, with the aid of technicians and experts, means of modernisation and speeding-up of the work to be done. The aim is by 1950 to bring production to a level 25 per cent higher than that of the peak year 1929. Out of the 2250 milliard* francs credit which will be expended, 1210 milliards will go to building and public works. The remaining 1040 milliard francs will be used for equipment and materials. A sum of 340 milliard francs is additional for maintenance of existing buildings. The credits will be distributed as follows:—Industry, 90 milliards; power, 135 milliards; transport and communications, 195 milliards; agriculture, 60 milliards; housing, 660 milliards; diverse constructions (social equipment, public buildings, &c.), 70 milliards; and maintenance work, 340 milliards. Half the programme is expected to be completed by 1950 and the whole by 1955. The labour force in the building industry will have to be increased to 980,000 in 1947 and 1,080,000 in 1950. At present the strength is 860,000, and it is likely that the programme for 1947 will not be fulfilled owing to the shortage. Mechanisation figures largely in the plan. By 1950 19,000 lorries and 25,000 light lorries will be used by the industry. Also 24,000 concrete mixers, 7500 building yard cranes, and 4400 fixed cranes will be added to equipment. Simplification of construction, industrialisation and the wide use of prefabrication and rationalisation also play a large part in the programme.

* * *

The great shortage of labour in France, where the 1947 deficit has been estimated at 580,000 units, has made the country look mainly to Italy for a source of labour. The immigration agreement which was recently signed by the Minister of Labour, Monsieur Ambroise Croizat, in Rome, gives Italian immigrants exceptional conditions, including 100 per cent family allowances for workers, transfer of wages to families in Italy, &c., which it is hoped will bring 200,000 Italians to France in 1947. The workers expected will mainly be employed in the mines, the metallurgical industry and agriculture. They will also be used, as the need is felt, in the building industry and for dam construction.

* 1 milliard = 100,000,000.

Notes and Memoranda

Rail and Road

AMERICAN RAILWAY RETURNS.—The Association of American Railroads says that in the month of January Class 1 railways had an estimated net income of 29,000,000 dollars, compared with 33,887,227 dollars in the corresponding month of 1946.

A CHESAPEAKE AND OHIO TUNNEL.—The boring of the longest double track tunnel on the Chesapeake and Ohio Railway has recently been completed. The tunnel, which is being constructed on the main line at Fort Spring, is approximately 2700ft long from portal to portal, and was driven from both ends through limestone containing clay seams. The tunnel will have a maximum width of 32ft and a maximum height of 26ft 6in, and, according to *Engineering News-Record*, is expected to be ready for traffic early in September.

PUBLIC WORKS, ROADS AND TRANSPORT CONGRESS.—A provisional programme has been published for the eleventh Public Works, Roads and Transport Congress, which is to be held from July 21st to 25th next at Olympia, London. The Exhibition in connection with the Congress will also take place at Olympia from July 21st to 26th. Eleven professional institutions associated with the work of public authorities, as well as the Royal Society for the Prevention of Accidents, will hold conferences during the run of the Congress, and altogether twenty-two papers will be presented for discussion. Nine of the papers deal with roads and bridges, including location, construction, surfacing, lighting and safety. Mr. C. W. Scott-Giles, 84, Eccleston Square, London, S.W.1, is the secretary of the Congress and Exhibition.

LONDON TRANSPORT DEVELOPMENTS. — In a recent speech at Southall, Mr. J. H. Brebner, chief public relations officer to the London Passenger Transport Board, outlined a programme of road and rail improvements now in hand. On the road transport side the L.P.T.B. intends to build new garages at Godstone, Hatfield, Shepherd's Bush, Kingston, Romford and Peckham, and to rebuild nine existing garages, the total cost of this part of the programme being about £6,000,000. With regard to railway services, the Central Line extension from Stratford to Leyton and Leytonstone is to be opened on May 5th, provision being made for 550 trains a day. The L.N.E.R. Ongar line trains will terminate at Leytonstone, where there will be platform interchange for L.N.E.R. passengers continuing their journeys by Central Line trains to Liverpool Street, the West End, Ealing Broadway and Wood Lane. Another extension of the Central Line—at the western end—is to be opened during the summer. This extension will branch off at North Acton and run over electrified G.W.R. track to Hanger Lane, Perivale and Greenford. Other items in the programme include extensive improvements at Liverpool Street Metropolitan and Central Line stations.

Miscellanea

BRUSSELS INTERNATIONAL FAIR.—The twenty-first Brussels International Fair opens to-morrow, April 26th, and will continue until May 11th. The stands are situated in several of the palaces at Heysel, built for the World's Exhibition in 1935.

DIESEL-ELECTRIC SHUNTING ENGINE. — With reference to the article on the Crompton-Parkinson diesel-electric locomotive, published in our issue of March 7th, we have been asked to state that the mechanical parts were built by Andrew Barclay and Co., Ltd., of Kilmarnock.

JOINT COMMITTEE IN ENGINEERING DESIGN.—As a result of proposals made by the Council of Industrial Design to the British Engineers' Association and the British Electrical and Allied Manufacturers' Association, a tripartite committee has been formed to consider improvements in the design of engineering capital equipment. The committee consists of three representatives of each organisation.

THE ZINC DEVELOPMENT ASSOCIATION.—The Zinc Development Association, Lincoln House, Turl Street, Oxford, has issued its annual report for 1945–46, giving an account of its work during the year and also of the work of the Zinc Alloy Die Casters' Association and the Zinc Pigment Development Association. The report surveys the various uses of zinc since the end of the war, noting, amongst other matters, that all established uses, especially galvanised coatings and rolled zinc, show a satisfactory increase. There is also reference to the fact that new applications of the metal, such as zinc metal-pigmented paints, have been expanded.

IRON AND STEEL INSTITUTE.—The annual general meeting of the Iron and Steel Institute will be held in London on Wednesday, Thursday and Friday, May 14th, 15th and 16th. The first day's sessions will begin at 10 a.m. and will take place at 4, Grosvenor Gardens, S.W.1, the subject for discussion being "The Hardenability of Steel." The second Hatfield Memorial Lecture will be delivered by Dr. C. Sykes on Wednesday evening at 8.30 p.m. at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1. The meeting will be resumed on Thursday morning, May 15th, at 9.55 a.m. at the Institution of Civil Engineers, when the official business and presentation of awards will be followed by the reading and discussion of papers. The technical discussions will be continued on Thursday afternoon at 2.30 p.m. and on Friday morning at 10.30 a.m. The Institute's dinner will be held at the Connaught Rooms, Great Queen Street, W.C.2, on Thursday evening, May 15th, at 7.15 for 7.45 p.m.

AMERICA'S IRON ORE IN 1946.—Strikes at iron mines, the Lake Superior shipping strike, and the effect of the steel and coal strikes on iron ore markets were responsible chiefly for a 19 per cent drop in iron ore output in the U.S.A. in 1946, according to the Bureau of Mines. Production of iron ore in 1946 was estimated at 71,214,000 gross tons, compared with 88,376,393 tons in 1945. Decreased output was apparent in all districts except in the south-eastern States, where the output was about 1 per cent above that of the previous year. The Lake Superior district, which supplies four-fifths of the domestic requirements, produced 21 per cent less iron ore than in 1945, the north-eastern States 28 per cent less, and the western States 21 per cent less. By-product ore, obtained from treating pyrites, was produced at about the same rate as in 1945, and totalled approximately 500,000 tons. Deliveries of iron ore in 1946 were estimated at 70,435,000 gross tons, 20 per cent less than in 1945. Stocks of iron ore at mines and mills on December 31, 1946, were estimated at 5,688,000 gross tons, compared with 4,803,234 tons at the end of 1945.

DIESEL ENGINE USERS ASSOCIATION.—There was a good attendance of members and guests at the luncheon of the Diesel Engine Users Association, at the Connaught Rooms, London, on Thursday of last week, April 17th. The President, Mr. Clifford Green, was in the chair and welcomed, as the Association's principal guest, Sir Lynden Macassey, K.C., independent Chairman of the British Internal Combustion Engine Manufacturers' Association. Sir Lynden, in acknowledging the toast of "The Guests," congratulated the D.E.U.A. upon the contribution it was making to the progress of the internal combustion engine industry, at the same time expressing a hope that the time might come when British oil engine supremacy should be emphasised by dropping the name "Diesel" altogether. Sir Lynden went on to survey the activities of the Manufacturers' Association which he represented, stressing the fact that there were many ways in which the two organisations of makers and users could co-operate to their mutual advantage. Thanks to Sir Lynden and to the President were very appropriately expressed by Mr. A. K. Bruce, a Past-President of the D.E.U.A.

GENERATION OF ELECTRICITY, MARCH, 1947.—The official returns rendered to the Electricity Commissioners show that 3983 million units of electricity were generated by authorised undertakers in Great Britain during the month of March, 1947, as compared with the revised figure of 3820 million units in the corresponding month of 1946, representing an increase of 163 million units, or 4·3 per cent. During the first three months of 1947 the total number of units generated by authorised undertakers was 12,334 million units, as compared with the revised figure of 11,424 million units for the corresponding period of 1946, representing an increase of 910 million units, or 8 per cent. The total number of units sent out from the generating stations of authorised undertakers during the month of March, 1947 (*i.e.*, units generated less units consumed in the stations by auxiliary plant and for lighting, &c.), was 3758 million units, as compared with the revised figure of 3608 million units in the corresponding month of 1946, representing an increase of 150 million units, or 4·2 per cent. During the first three months of 1947 (*i.e.*, up to the end of March) the total number of units sent out from the generating stations of authorised undertakers was 11,656 million units, as compared with the revised figure of 10,797 million units for the corresponding period of 1946, representing an increase of 859 million units, or 8 per cent.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

British Industries Fair

Monday, May 5th, to Friday, May 16th.—London, Olympia and Earls Court; Birmingham, Engineering and Hardware Section, Castle Bromwich, Birmingham.

Chemical Society

Thursday, May 1st—Burlington House, Piccadilly, W.1. "Nitration of Olefines," C. W. Scaife; "Reactions of the Nitroparaffins," A. Lambert; "Addition Reactions of Nitro Olefines," R. L. Heath; "Formation and Reduction of Two and Three-Nitro Alkyl Cyanides," G. D. Buckley. 7.30 p.m.

Illuminating Engineering Society

Friday, May 9th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "The Physical Nature of Light," J. Cull. 6 p.m.

Tuesday, May 13th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. Annual general meeting. 6 p.m.

Institute of Metals

Wednesday, May 21st.—Institution of Civil Engineers, Great George Street, S.W.1. "Metallurgical Problems Involved in the Generation of Useful Power from Atomic Energy," Sir Wallace Akers. 6 p.m.

Institute of Welding

Wednesday, April 30th.—Institution of Civil Engineers, Great George Street, S.W.1. "The Welding of Copper and the Copper-Rich Alloys," M. Cook and E. Davis. 6 p.m. (Joint meeting.)

Institution of Chemical Engineers

Tuesday, May 6th.—Geological Society, Burlington House, Piccadilly, W.1. "The Reuse of Waste Waters from Industrial Processes," B. A. Southgate. 2.15 p.m.

Institution of Civil Engineers

To-day, April 25th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield. "Soil Mechanics," N. S. Boulton. 7 p.m.

Tuesday, April 29th.—Great George Street, S.W.1. "Captain Cook Graving Dock, Sydney," J. Guthrie Brown, and "Sturrock Graving Dock, Cape Town," D. E. Paterson. 5.30 p.m.

Wednesday, April 30th.—N. WESTERN ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester. Annual Dinner. 6.30 p.m.

Institution of Electrical Engineers

Saturday, April 26th.—N. MIDLAND STUDENTS: Corporation Electricity Department, Whitehall Road, Leeds. "Mine Lighting," O. Seymour. 2.30 p.m.

Friday, May 2nd.—N.-EASTERN STUDENTS' SECTION: County Hotel, Newcastle-on-Tyne. Annual general meeting and annual dinner. 6.45 p.m.

Wednesday, May 7th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "Accurate Measurement of the Group Velocity of Radio Waves in the Atmosphere, Using Radar Technique," R. A. Smith, E. Franklin and F. B. Whiting. 5.30 p.m.

Tuesday, May 13th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Future Trend of Component Design for the Services." 5.30 p.m.

Saturday, May 17th.—N. MIDLAND STUDENTS: City Electricity Department, Whitehall Road, Leeds, 1. Annual general meeting and films afternoon. 2.30 p.m.

Institution of Heating and Ventilating Engineers

Wednesday, April 30th.—LIVERPOOL BRANCH: Accountants' Hall, Fenwick Street, Liverpool. "Feed Water Treatment," R. Williams. 6.30 p.m.

Tuesday, May 6th.—LONDON ASSOCIATE MEMBERS AND GRADUATES' SECTION: Junior Institution of Engineers, 39, Victoria Street, S.W.1. "Hot Water Supply by Electricity," J. I. Bernard. 6 p.m.

Institution of Mechanical Engineers

To-day, April 25th.—Storey's Gate, St. James's Park, S.W.1. "Stress Concentration and Fatigue Failures," Professor S. Timoshenko. 5.30 p.m.

Saturday, April 26th.—N. WESTERN GRADUATES: **Engineers' Club, Albert Square, Manchester. "Electronics for the Mechanical Engineer," K. M. Fantom. 2.30 p.m.**

Thursday, May 1st.—GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1. "Statistical Quality Control," E. A. Ritchie. 6.30 p.m.

Institution of Post Office Electrical Engineers

Monday, April 28th.—Faraday Building (South Block), Knightrider Street, E.C.4. "Repeater Station Power Supplies," K. W. Hix. 5 p.m.

Institution of Production Engineers

To-day, April 25th.—LINCOLN SUB-SECTION: Lincoln Technical College, Lincoln. "X-Rays in Industry," J. L. Mullins. 6.30 p.m.

Thursday, May 1st.—NOTTINGHAM SECTION: Victoria Station Hotel, Nottingham. Annual general meeting. 7 p.m.

Thursday, May 8th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "A Practical Approach of Research to Industry," H. W. Hobbs. 6.30 p.m.

Saturday, May 10th.—YORKSHIRE GRADUATES: Great Northern Hotel, Leeds. Annual general meeting and Luncheon. 1 p.m.

Monday, May 19th.—DERBY SUB-SECTION: Art School, Green Lane, Derby. "Lay-Out of Factory and Plant for Efficient Production," S. Gilbert. 6.45 p.m.

Iron and Steel Institute

Wednesday, May 14th.—Institution of Civil Engineers, Great George Street, S.W.1. Second Hatfield Memorial Lecture. "Steels for Use at Elevated Temperatures," Dr. C. Sykes. 8.30 p.m.

Wednesday to Friday, May 14th to 16th—Annual Meeting in London. For programme, see page 367.

Junior Institution of Engineers

To-day, April 25th.—**Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Annual Dinner. 6.45 p.m.**

Friday, May 2nd.—39, Victoria Street, S.W.1. "The Post Mill," Rex Wailes. 6.30 p.m.

Friday, May 9th.—Institution of Civil Engineers, Great George Street, S.W.1. "The Synthesis of Oil from Coal by the Fischer-Tropsche Process," C. C. Hall. 6.30 p.m.

London Association of Engineers

Saturday, May 3rd.—Charing Cross Hotel, W.C.2. "Precision Measuring Instruments," C. O. Tayler-son. 6.30 p.m.

Manchester Statistical Society

To-day, April 25th.—INDUSTRIAL GROUP: Society of Architects, 16, St. Mary's Parsonage, Deansgate, Manchester. "Probability and the Experimenter," E. D. van Rest. 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Monday, April 28th.—Mining Institute, Newcastle-upon-Tyne. "Some Model and Full Scale Experiments on Side Launching," F. H. Todd and E. Laws. 6 p.m.

North of England Institute of Mining and Mechanical Engineers

Saturday, April 26th.—ASSOCIATES' AND STUDENTS' SECTION: Neville Hall, Newcastle-on-Tyne, 1. "Composite Working in Thin Seams," Thomas Kidd, and "Coal Preparation at the Face," K. D. Craig. 2.30 p.m.

Sheffield Metallurgical Association

Tuesday, April 29th.—**198, West Street, Sheffield. "Springs for High Duty Purposes," Brinley Jones. 6.30 p.m.**

Tuesday, May 6th.—198, West Street, Sheffield, 1. "Heat-Resisting Steels," D. A. Oliver. 6.30 p.m.

Society of Chemical Industry

Thursday, May 15th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Sawdust Cement and Other Sawdust Building Products," Dr. T. W. Parker. 6 p.m.

Women's Engineering Society

Thursday, May 8th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester. "Capacitors: Their Manufacture and Testing," Miss W. Hackett. 6.30 p.m.

Friday, May 16th.—35, Grosvenor Place, S.W.1. "Women in Post-War Engineering." 7 p.m.

Personal and Business

MR. F. E. HOUGH has been appointed chief mechanical engineer, Rhodesia Railways.

MR. J. S. HUTCHISON has been appointed vice-chairman of the British Oxygen Company, Ltd.

MACROME, Ltd., states that its head office address is Aldersley, Wolverhampton (telephone, Tettenhall 52001).

THE BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION states that its telephone number will be changed on May 1st to Euston 6411.

ELLIOTT BROTHERS (LONDON), Ltd., announces that the address of its Birmingham office has been changed to 9, Caroline Street, Birmingham, 3 (telephone, Birmingham 2037).

THE LAMSON ENGINEERING COMPANY, Ltd., announces the retirement of Mr. W. H. Bothamley, South London and S.E. England representative, after forty-three years' service.

MR. G. H. LATHAM, chairman and managing director of the Whitehead Iron and Steel Company, Ltd., has been appointed President of the British Iron and Steel Research Association.

THE LONDON AND NORTH-EASTERN RAILWAY COMPANY announces the following appointments:—Mr. G. B. Barton, assistant chief engineer, in succession to Mr. F. E. Harrison, who is retiring; Mr. J. I. Campbell, engineer (London), in succession to Mr. Barton.

MULLARD WIRELESS SERVICE COMPANY, Ltd., announces the formation of a new company to be known as Electronic Transmission Equipment, Ltd. The new company will develop and manufacture communications apparatus at Brathway Road, Wandsworth, S.W.18.

MR. C. F. J. FRANCIS-CARTER has resigned his post as director and general manager of the Metal and Produce Recovery Depots, and has been appointed general manager of the newly formed Aluminium Wire and Cable Company, Ltd., Port Tennant Works, Swansea.

ENGINEER-CAPTAIN J. C. BRAND, R.A.N. Ret., M.I. Mech. E., M.I.N.A., formerly consulting and inspecting engineer to the Commonwealth Government and assistant chief inspector of armaments during the war, is returning to Australia early in June to resume practice in Sydney.

Reports on German Industry

Limited numbers of copies of the reports of Intelligence Objectives Sub-Committees on German Industry listed below can be obtained from H.M. Stationery Office at the prices stated.

No. of report.	Title.	Post free.
F.I.A.T.:		
292	The Manufacture of Laboratory Apparatus, Instruments and Equipment	1 7
556	Some Aspects of Rayon and Synthetic Fabric Dyeing and Processing in Germany and Austria	5 2
593	The 16-Cylinder Air-Cooled Diesel Engine of the Simmering Graz Pauker A.G.	2 8
704	Final Summary of the Sub-Committee for Shipbuilding in Germany	1 7
B.I.O.S.		
603	The Investigation in Germany of Technical Developments in Prefabricated Housing	5 8
737	The Investigation of Cast Iron Roll Manufacture in Germany, with Notes on the Usage in Rolling Mill Plants	11 9
766	The Manufacture of Pharmaceuticals and Fine Chemicals in the U.S. and French Zones of Germany	35 7
796	Coated, Gummed and Fancy Paper and Board Mills	4 8
812	Observations on Sugar Factory Equipment in the British Zone in Germany	2 8
816	Gewerkschaft Rheinpreussen Utfort/Moers: Tar Distillation ...	0 7
822	Shipbuilding: Notes on Visits to Blohm and Voss, Deutsche Werft, Germania Werft and Deschimag	2 8
831	Heat Treatment of Refractory Materials	2 8
837	Design, Construction and Production of High-Speed Centrifuges	1 7
841	Synthetic Rubber: Developing and Testing at the I.G. Central Rubber Laboratory, Leverkusen, Interrogation of Dr. P. Stocklin and Dr. H. Roelig	1 1
859	German "Stellite" Type Alloys...	1 1
F.I.A.T.:		
71	Medical Targets in Central and Southern Germany	8 3
717	Buna Rubber Research	5 8
762	New Plastics for German Aircraft (Structural Materials, Glazings and Paints)	1 7
826	The Reproduction of Contrast through Telescopes	3 8
C.I.O.S.: XXVII–10 ...	Hanomag, Hanover: Manufacture of Shell Driving Bands Using Iron Powder	2 1
B.I.O.S.:		
409	D.C. Cup Type Motors, by Siemens Schuckert Zachlerwerk, Nuernberg	1 7
606	The Design of German Telephone Subscribers' Apparatus	5 8
611	Utilisation of Washery Refuse as Boiler Fuel in Ruhr Coal Mines	2 2
642	Performance of Pfauter Hobbing Machine Employing "Giant" Hobs: Supplementary to B.I.O.S. 442	1 1
661	Manufacture of Vulcanisation Accelerators and Antioxidants	2 1
663	Manufacture of Synthetic Resins by I.G. Farbenindustrie, Ludwigshafen	0 7
667	I.G. Farbenindustrie Mainkur: Miscellaneous Chemicals (Insecticides, Textile Agents, Oils)	1 1
668	"Eumuco" Shell Forging Press Usage	1 7
678	Manufacture of Cement and Sulphuric Acid from Anhydrite: I.G. Farbenfabrik, Wolfen ...	3 8
687	The Design of German Line Telecommunications Transmission Systems	15 4
709	The Production of Tetranitromethane and Nitroform at I.G. Farbenindustrie, Hoechst - am - Main: Alternative Compound to Nitric Acid for Use as an Oxygen Donator in the V Weapons	1 7

During the past few months amendments and addenda to the following reports have been issued and made available at H.M. Stationery Office sales offices:—C.I.O.S. Nos. XXVIII–18, XXXIII–23; B.I.O.S. Nos. 35, 135, 199, 217, 307, 340, 345, 363, 405, 422, 423, 429, 438, 450, 468, 507, 572, 591, 773; F.I.A.T. No. 273.

An almost complete set of German patent specifications, accepted by the Berlin Patent Office during the war, has been secured for the United Kingdom. The specifications, for which either annual or weekly subject-matter and name indices are available, can be seen by the public at the Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.2. Both the indices and the specifications are in German. Photographic copies of any specification and drawings may be obtained at the rate of 6d. per page.

A Seven-Day Journal

P.I.C.A.O. Report on Navigational Aids

THE Special Radio Technical Division of P.I.C.A.O. (Provisional International Civil Aviation Organisation) has recently issued a final report covering its first session in Montreal. It will be recalled that the purpose of the Montreal session was to consider and make recommendations upon the suitability for civil aviation of the various radio and radar navigational aids, with the ultimate object of securing standardisation. Substantial agreement was reached on four matters—instrument approach and landing aids, short and long range navigational aids, and aerodrome aids. Space forbids a detailed analysis of the report, which, in addition to five appendices, comprises ten sections dealing with functional requirements, factors in the evaluation of proposed navigational aids, general considerations in the selection of systems for international standardisation, aids to final approach and landing, short distance aids, long distance aids, radio aids for use in the movement area, possible future trends in radio aids, VHF radio-telegraph transmission, recommendations and resolutions. To stimulate research and development, the report recommends that an office be formed within the Secretariat of P.I.C.A.O. to be responsible for collecting from and disseminating to member States current information on new devices of value to international air navigation and traffic control. Since the division was unable to establish firm and detailed installation programmes, it is recommended that the development of such programmes should proceed regionally. To co-ordinate development of secondary radar equipment the Division recommends that an exchange of personnel should take place between States engaged in development work. Finally, it is recommended that a standing commission should be set up to pursue the development and evaluation of short-distance aids; and that a separate standing commission should be established to guide, observe, and analyse progress in long-distance aids, bearing in mind that no such aid is at present sufficiently proven to justify its acceptance as a word-wide standard. Copies of the report (3s. 9d.) are obtainable from Mr. E. M. Lewis, P.I.C.A.O. Representative, North Atlantic Regional Office, 7, Fitzwilliam Place, Dublin.

The Institute of Fuel: Building Fund Appeal

As is known to many of our readers, the Institute of Fuel has recently moved from its temporary wartime address at 30, Bramham Gardens, S.W.5, to its own premises at No. 18, Devonshire Street, London, W.1. At the new headquarters the Institute has a members' room and library, a council chamber and committee room, as well as adequate office accommodation. Situated between Harley Street and Portland Place, the new Institute building is only four minutes' walk from Regent's Park Station on the Bakerloo Line. The acquisition of the premises has been made possible through the generosity of one of the Institute's collective members, who has bought the lease on behalf of the Institute for the sum of £21,400. The Council has promised to find that sum as soon as possible. It estimates that, after minimum decorations, alterations and furnishings are completed, the sum of £25,000 will be required. With the object of obtaining that sum, an appeal has now been made to each and every member of the Institute, and the hope is expressed that everyone will respond as generously as possible. It is satisfactory to learn from the Secretary of the Institute, Mr. R. W. Reynolds-Davies, that before launching the Building Fund Appeal close upon £9000 has been received in the form of contributions to the fund, from a wide range of supporters of the work of the Institute, in the solid fuel, gas, oil and electricity producing and operating industries, and the general engineering industries. An appeal committee has been formed under the chairmanship of Sir Ernest Smith, C.B.E. The members of the committee are Dr. C. H. Lander, C.B.E., president; Mr. R. H. Gummer, honorary treasurer, and Mr. J. F. Ronca, honorary secretary.

Foreshore and Coast Erosion

ON Friday, April 25th, it was officially announced by the Ministry of Transport that an Order under the Ministers of the Crown (Transfer of Functions) Act, 1946, has been made which transfers to the Minister of Health for England and Wales, and to the Secretary of State for Scotland, as from April 16th, 1947, all functions exercisable by the Minister of Transport in relation to the protection of the coast and tidal lands in England and Wales and in Scotland against erosion or other damage caused by action of the sea. The duties of the Minister of Transport in the management of Crown foreshore and river and sea bed are being undertaken by the Commissioners of Crown Lands at 1, Cambridge Gate, Regent's Park, N.W.1. The consent of the Minister of Transport in the interests of navigation should, however, continue to be sought, for the construction of any work which will extend below the high-water mark of ordinary spring tides.

Rocket-Propelled Robot Aircraft

SOME further technical particulars concerning the series of tests with rocket-propelled robot aircraft, designed by the research staff of Vickers-Armstrong, Ltd., which will be made from the Scilly Isles in the course of a few weeks' time, were given by Sir Ben Lockspeiser, Chief Scientist of the Ministry of Supply, in London, on Tuesday, April 29th. He said that the experiments would provide invaluable information concerning the problems of flying at transonic and supersonic speeds. They should not only provide data relating to advancement through the supersonic barrier, but also of decelerating back-to-subsonic speeds. It has already been revealed that the rocket-propelled machines will be airborne by a "Mosquito" aircraft to a height of about 36,000ft, at which height they will be released for tests within a radius of 11½ miles from the Bishop Rock in the Scilly Isles, during the coming six months. After being allowed to glide down for about 1000ft after release, the bi-fuel rocket motor will be automatically switched on and the robot aircraft will then travel at high speed for a period of just over a minute, reaching a maximum of 900 m.p.h. before its fuel is expended. At this high speed it will cover a level course of about 15 miles. An automatic pilot will then cause the robot machine to dive into the sea. Special instruments within the aircraft will enable readings to be recorded at a ground station in the Scilly Isles, radar will be employed to track its path and an attempt to photograph it in flight will be made from a "Meteor" jet-propelled fighter. It was further stated by Mr. B. N. Wallis, chief of Vickers-Armstrong's research staff, that at 900 m.p.h. the rocket motor should develop about 2000 h.p. and the flame temperature of the jet would be about 2000 deg. Cent., the gases being accelerated to a speed of about 5000ft per second. During the tests various types of robot aircraft are to be tried out in batches of six.

The Kelvin Lecture

AT an ordinary meeting of the Institution of Electrical Engineers a large audience of electrical engineers and physicists gathered in the Kingsway Hall, on Thursday, April 24th to hear the thirty-eighth Kelvin Lecture, which this year was delivered by Professor L. B. Loeb, B.Sc., Ph.D., who spoke on "Electrical Discharge Through Gases." The lecture was preceded by the presentation by the President of two I.E.E. awards—the Certificate of Honorary Membership and the Faraday Medal. The President said that the distinction of honorary membership had been conferred upon Sir John MacFarlane Kennedy, O.B.E., in recognition of his distinguished work in the sphere of electricity supply and of his services to the Institution. The President then made the award of the Faraday Medal to Sir Standen Leonard Pearce, C.B.E., D.Sc., for his outstanding contributions to the advancement of engineering practice and his notable achievements in electrical engineering. Introducing Professor Loeb, the President reminded the audience that the Kelvin Lecture, which was delivered annually, had been inaugurated in 1908 with the dual purpose of helping members of the I.E.E. to keep in touch with the latest developments in the adjacent realm of physics, and of commemorating the name of Lord Kelvin. Professor Loeb was a distinguished physicist, who, since 1929, had been Professor of Physics at the University of California, except for a period from 1941 to 1945, when he served in the U.S. Naval Reserve. Professor Loeb's lecture contained a comprehensive *résumé* of half a century's research work into the mechanism of electrical discharge through gases. The lecturer called attention to those aspects of the subject that were of more direct interest to electrical engineers who were concerned with such applications as gas-filled relays, discharge lighting, cathode ray tubes and mercury arc rectifiers. Professor Loeb indicated some of the gaps in our existing knowledge and referred to the extensive and fascinating field that still lay unexplored before research workers on discharge phenomena.

Summer Fuel Restrictions

SPEAKING in the House of Commons on Thursday, April 24th, Mr. Shinwell, the Minister of Fuel and Power, outlined the general framework of the Ministry's plan to build up during the summer months stocks of coal for the winter. The situation was, he said, of such gravity that it could only be met by a great united effort on the part of the whole nation, fuel producers and fuel consumers alike. The first part of the plan, which is implemented by the Statutory Order issued on Monday, April 28th, imposes a complete statutory prohibition on the use of space heating of any kind, both in industrial and commercial premises, from May 5th, when the new Order comes into force, until the end of October. Certain exceptions are made in industries calling for space heating during processing, handling and storage. In order to meet the needs of night workers the Order permits the use of fuel for heating between 10 p.m. and 8 a.m. during May, September and October. The Order also imposes a ban on the use of gas and electricity for space heating purposes in residential premises until the end of September, subject to relaxation only where current is generated by water power and not supplied to the grid, or by non-authorised undertakers who generate without the use of coal or oil, or when a medical certificate is given. Further, all domestic consumers of gas and electricity are asked to aim at saving 25 per cent of the amounts they consumed in the comparable period last year. Guidance as to meter reading and as to the use of various gas and electricity appliances and their respective consumption rates will be issued. The gas and electricity industries, although their views have not been met in all respects, have promised their fullest co-operation. Finally, non-industrial and commercial groups of consumers, shops, offices, places of entertainment, catering establishments, &c. are relied upon to make sacrifices at least equal to those asked from domestic consumers. The Ministry of Fuel and Power states that about one million tons of fuel can be saved by the prohibition of space heating in industrial premises during the summer.

An Analysis of Surface Condenser Performance

By R. W. HAYWOOD, M.A., B.Sc., Wh.Sc., A.M.I. Mech. E.*

No. I

DETERIORATION in the performance of a surface condenser may result from air leakage into the plant or from dirtiness of the condenser tubes. The extent to which either of these two factors is influencing the performance at any given time is, however, usually a matter of some uncertainty. This state of uncertainty arises from the fact that the vacuum also varies with steam duty, circulating water quantity and circulating water temperature, and may also be affected by the capacity of the air ejector or pump.

This article makes a theoretical investigation into the effects of these variables on the overall performance of the condensing plant, with confirmatory data obtained on some typical modern condensers, and suggests the use of a simple electrical distance thermometer indicator as a means of keeping a check on the performance as it is affected by air leakage and tube dirtiness.

Effect of Air Leakage into a Condenser

It is well known that air leakage into a condenser results in a depression of the condensate outlet temperature below the steam inlet temperature, and it is appropriate to examine afresh exactly how this is brought about.

With modern condensers, the condensate outlet temperature may be considered for most purposes to be equal to the steam inlet temperature in an air-free condenser; undercooling of the condensate due to contact with the lower temperature tubes at the bottom of the condenser being prevented by providing adequate steam lanes penetrating right down into the condenser tube nest, as illustrated in Fig. 1. In this way, the condensed steam, as it falls or is swept off the tubes, is at all points brought into contact with uncondensed steam. Thus, though the condensed steam on the lower and cooler tubes may be cooled below the vacuum temperature whilst it is actually in contact with the tubes, as it falls down to the bottom of the condenser it is heated up again to virtually full vacuum temperature by the oncoming draught of uncondensed steam, condensing some of it in the process. It will be seen later that the behaviour when air is admitted into the condenser provides verification that this undercooling and reheating does take place.

When a mixture of steam and air is brought into the condenser, the absolute pressure at any point in the condenser is equal to the sum of the partial pressures of the steam and of the air, in accordance with Dalton's Law of Partial Pressures. Furthermore, the temperature at a given point is determined by the partial pressure of the steam at that point, being equal to the saturation temperature corresponding to that partial pressure.

At inlet to the condenser, before any of the steam has been condensed, the proportion of air to steam is infinitesimally small. The partial pressure of the air is therefore negligible, and the partial pressure of the steam is virtually equal to the total pressure. The temperature at condenser inlet consequently remains unaltered at the full vacuum temperature.

When the steam commences to condense, however, the proportion by weight of air to uncondensed steam increases, and the partial pressure of the air therefore increases as condensation proceeds. Simultaneously the partial pressure of the steam decreases, so that the temperature of the steam is also decreasing the further it penetrates towards the bottom of the condenser. Thus at any point in the condenser, the process of condensation now presents a somewhat complicated picture, made up of steam being condensed at a pressure, and therefore temperature, lower than that at which it is being condensed higher up; also of the steam which has been condensed higher up falling as water

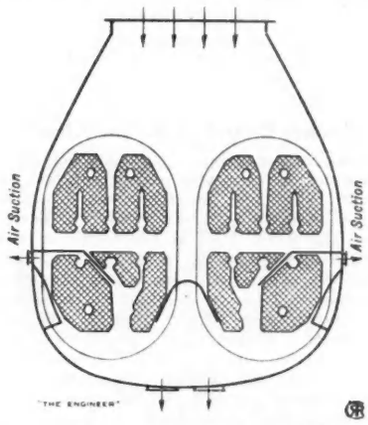


FIG. 1—CIRCULATION IN CONDENSER

into a space where its temperature exceeds the equilibrium or saturation temperature at the prevailing partial pressure. Of the latter, that which does not come into contact with the tubes is cooled by mixing with the lower temperature water and by partial re-evaporation, whilst that which comes into contact with the tubes is cooled by giving up its heat to the circulating water. Some of this is doubtless undercooled, but is heated up again by the oncoming draught of uncondensed steam, condensing some of it in the process. Now, however, this oncoming steam is at a lower temperature by virtue of its reduced partial pressure, so that the steam already condensed is no longer restored to the full vacuum temperature existing at the top of the condenser, the final temperature of the condensate at the bottom of the condenser depending on the amount of air present. The heat resulting from the reduction in the condensate temperature below the steam inlet temperature is thus lost to the circulating water, and it is interesting to note how the presence of a small amount of air causes the circulating water to take up from the condensed steam this heat, which it cannot take up in the absence of any air. Thus air in a condenser causes a double loss in efficiency, first, due to the reduction in vacuum, and, secondly, due to this extra rejection of heat to the circulating water.

Having examined the mechanism by which this reduction in condensate temperature is brought about, it is of interest to determine its magnitude theoretically.

Let W_A be the weight of air present per pound of uncondensed steam at the bottom of the condenser. If V_s cubic feet per pound is the specific volume of the steam, then the W_A pounds of air will, by Dalton's Law of Partial Pressures, also occupy V_s cubic feet.

If P_s pounds per square foot is the partial pressure of the steam, then both the steam and air will be at the saturation temperature, T_s deg. Fah. absolute, of the steam at this partial pressure.

Applying the equation $PV=mRT$, the partial pressure of the air is thus given by

$$P_A=RT_s/V_s \cdot W_A \text{ lb per square foot} \quad . \quad (1)$$

where

R=gas constant=53·3 foot-pounds per pound per deg. Fah. for air.

It has been seen above that the reduction in condensate temperature below the inlet steam temperature is equal to the difference between the saturation temperature corresponding to the total pressure in the condenser and the saturation temperature corresponding to the partial pressure of the steam at the bottom of the condenser. Thus this temperature difference will be equal to the reduction in saturation temperature resulting from a reduction in steam pressure equal in magnitude to P_A. A simple relation may be established for the change δT_s in saturation temperature resulting from a small change in steam pressure δP as follows:—

First, the total heat H is defined by the equation

$$H=E+PV/J,$$

where

J=mechanical equivalent of heat=778 foot-pounds per pound per B.Th.U.

Whence, for an adiabatic expansion

$$\delta H=V/J \cdot \delta P \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Secondly, since wet steam is always at the saturation temperature T_s, regardless of the degree of wetness, its total heat is given by

$$H=H_s-T_s(\phi_s-\phi),$$

where ϕ is its entropy, or

$$H=T_s\phi-G_s,$$

where G_s=negative thermodynamic potential defined as $T\phi-H$.

Therefore

$$\delta H=T_s\delta\phi+\phi\delta T_s-\delta G_s$$

In an adiabatic expansion, $\delta\phi=0$, so that

$$dH/dT_s=\phi-dG_s/dT_s=\phi-\lambda \quad . \quad . \quad (3)$$

where $\lambda=dG_s/dT_s$.

Combining equations (2) and (3), when $V=V_s$ and $\phi=\phi_s$,

$$\delta T_s=V_s/J\,(\phi_s-\lambda) \cdot \delta P \quad . \quad . \quad . \quad . \quad (4)$$

Thus the difference θ_c between the steam inlet and condensate outlet temperatures, resulting from a partial air pressure P_A at the bottom of the condenser, will be given for small values of P_A by

$$\theta_c=V_s/J\,(\phi_s-\lambda) \cdot P_A \quad . \quad . \quad . \quad . \quad (5)$$

Inserting the value of P_A from equation (1),

$$\theta_c=RT_s/J\,(\phi_s-\lambda) \cdot W_A=\mu W_A \quad . \quad (6)$$

where

$$\mu=RT_s/J(\phi_s-\lambda) \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The values of T_s, ϕ_s, λ and μ are tabulated in Table I for vacua of 29·5in Hg. and 26·0in Hg.

TABLE I.—*Variation of μ with Vacuum*

Vacuum, in Hg (bar. 30in)				29·5			26·0
T_s deg. Fah. abs.				518·5			585·0
ϕ_s				2·098			1·922
λ				0·05			0·16
μ				17·3			22·7

It will be seen that the value of μ does not change greatly for wide variations in vacuum,

* Formerly chief steam turbine test engineer, English Electric Company, Ltd., Rugby. Now university demonstrator in engineering, Cambridge.

and the general statement may be made that a 5 per cent mixture by weight of air to uncondensed steam will cause a reduction of the condensate outlet temperature below the inlet steam temperature of 1 deg. Fah. over the range of vacua commonly met with. As the amount of uncondensed steam is itself a completely unknown quantity in any condenser, this statement may at first seem somewhat unhelpful. The point to note, however, is that the depression in condensate temperature is practically the same for a given percentage mixture, independently of the vacuum obtaining; this fact will be of assistance in interpreting the phenomena observed below in tests on a typical modern condenser.

Before examining curves showing the actual effect of introducing air into a condenser, it is necessary to qualify slightly the earlier statement that the condensate temperature may be considered to be equal to the steam inlet temperature in a modern condenser when there is no air leakage. It is true that this is frequently achieved but it does not necessarily hold under all conditions. It is clear, for example, that there is a greater likelihood of pure under-cooling the greater is the value of θ_1, the difference between the inlet steam temperature and the temperature of the inlet circulating water passing through the lower tubes. When the results shown in Figs. 2 and 3 were obtained, θ_1 was approximately 32 deg. Fah., against a figure under design conditions of 19 deg. Fah., and it is believed that the initial value of θ_c of 2·3 deg. Fah. in Fig. 3 arose from pure undercooling consequent upon this high value of θ_1, and that air leakage was absent at this point, or, more accurately, not sufficient to produce any measurable depression in condensate temperature. This is substantiated by the subsequent behaviour of θ_c.

Figs. 2 and 3 show the effect of the introduction of air into a 30,000 square feet condenser under approximately constant load conditions. The curve labelled "Gradual Admission" was obtained by opening the air cock in small successive steps, allowing conditions to settle down after each increase in opening; while that labelled "Rapid Admission" was taken when the air cock was opened wide at the outset, and the back pressure allowed to rise without a break. The difference in behaviour under the two conditions is interesting.

It will be seen from Fig. 3 that when air was admitted in small successive steps the temperature difference θ_c unexpectedly first decreased slightly before starting to increase rapidly with further admission of air. As admission of air would be expected to result in an increase in W_A (the weight of air present per pound of uncondensed steam), and since the value of θ_c due to air leakage has been shown above to be directly proportional to W_A virtually independently of the vacuum obtaining, it might have been expected that θ_c would have increased from the start. The explanation of the initial decrease in θ_c would appear to lie in the effect on the initial undercooling of the reduction in heat transfer rate from steam to tube wall resulting from the blanketing of the tubes by a layer of air. This will tend to decrease the amount of pure undercooling, and it appears that this tendency first predominates over the depression in condensate temperature due to the partial pressure effect, but that the latter soon gains hold and leads to a continuous and rapid rise in θ_c.

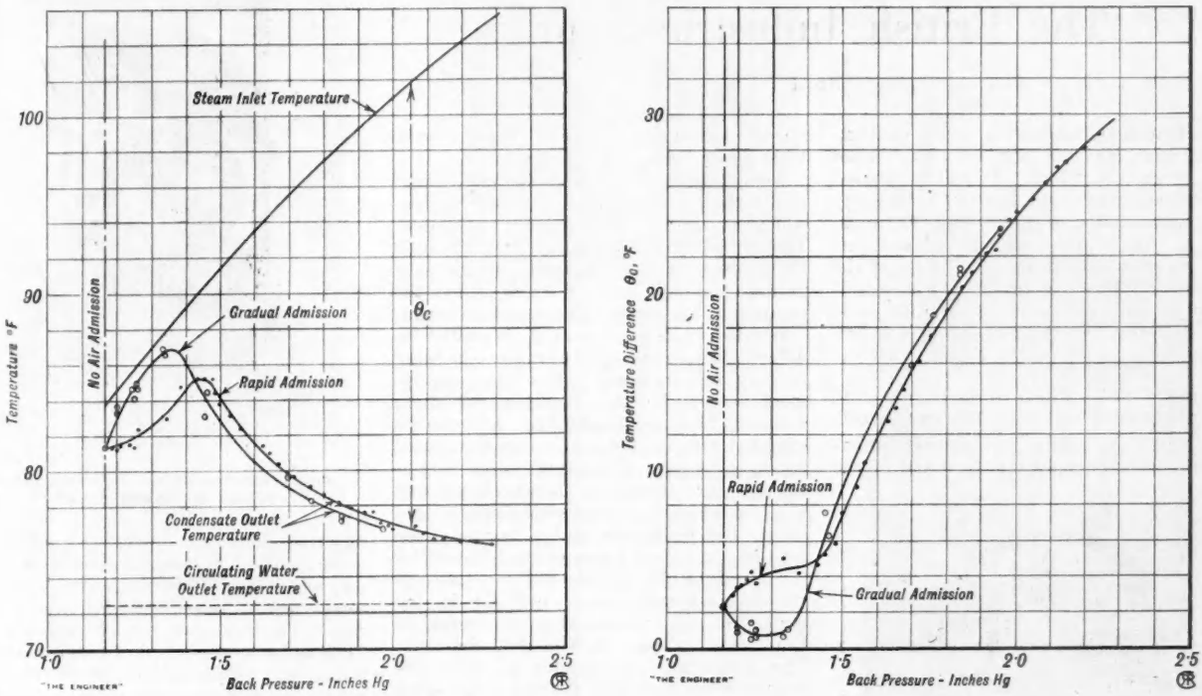
This explanation receives confirmation from the difference between the curves labelled "Gradual Admission" and "Rapid Admission" in Figs. 2 and 3. When the air is admitted gradually time is allowed for it to disperse amongst the tubes and for conditions to settle down and the effect on the initial undercooling resulting from the reduced rate of heat transfer is at first in evidence by the reduction in θ_c. When, however, the air is admitted rapidly and without pause it does not have the same time to disperse among and blanket the tubes, so that this secondary effect does not have the same opportunity to make itself felt and θ_c rises continuously from the outset, though at a low initial rate. Ultimately the two curves for gradual and rapid admission practically coincide with each other beyond the point where admission of more air has presumably no further effect on the rate of heat transfer.

The above explanation receives further confirmation from another effect which was observed, namely, that there was a momentary initial rise in θ_c followed by a fall, each time the air cock was opened a little wider, for again the air takes some little time to disperse among and blanket the tubes.

Had there been zero initial undercooling, θ_c would, of course, have increased from the outset under both gradual and rapid conditions of air admission, though again at a low initial rate.

It is seen from Fig. 2 that as the steam inlet temperature rose with increasing back pressure, the condensate temperature, while lagging behind, first rose with it, but very shortly took a downward turn as the effect of the depression of condensate temperature below the steam temperature predominated over the rise in vacuum temperature with increasing air leakage. As air leakage increased further the reduction in condensate temperature was ultimately limited by the circulating water temperature, while θ_c continued to increase as a result of the rise in vacuum temperature. In the tests under review the condensate temperature ceased to fall when it had reached a point approximating to the circulating water outlet temperature, though there appears to be no reason why, in some cases, it should not fall below this, the absolute lower limit (unattainable in practice) being the temperature of the inlet circulating water which passes through the lower tubes.

On different condensers the precise behaviour of θ_c with increase in back pressure due to air leakage will depend upon the design of the condenser and on the performance of the air ejector. However, the considerations outlined above apply in general to all plants, and experience has shown that a record of θ_c provides a good check on the airtightness of the condenser. It has, in fact, been found in modern high vacuum plants that readings of as much as 15 deg. to 20 deg. Fah. have existed where air leakage has actually passed otherwise unnoticed, for



FIGS. 2 AND 3—EFFECT OF INTRODUCTION OF AIR INTO CONDENSER

although the vacuum has not been as high as it should be, the condenser has still appeared to be maintaining a good vacuum. Nevertheless, it is not common practice to keep a record of θ_c, although this lends itself conveniently to direct reading on an electrical distance thermometer, in which two platinum resistance thermometers inserted in the steam inlet and condensate outlet branches respectively are connected in opposite arms of a Wheatstone bridge. The investigations described above were carried out with the aid of such an instrument, which was kindly loaned by the Cambridge Instrument Company, Ltd.

It should be noted that only the presence of air in the condenser itself can be detected by θ_c, but not leakages which find their way into the ejector without ultimately entering the condenser, such as would result from a leaking joint in the ejector body or in the air suction line or from a faulty stabilising valve. Usually such leakages can only be established by a process of elimination of suspected causes of poor performance of the plant, and a record of θ_c helps in this process.

Emphasis has been placed on the importance of eliminating air leakages, whatever their origin, as a check can only be kept on the dirtiness of a condenser if the vacuum is being determined from thermodynamic considerations of the condenser performance, but not if there is a limitation on the vacuum imposed by the air ejector in consequence of excessive air leakage or faulty operation. The second part of this article will examine the possibility of keeping a check on the dirtiness of an air-free condenser by a simple temperature differential measurement, similar to that described above for detecting air leakage.

(To be continued)

The British Industries Fair

No. I

THE British Industries Fair opens on Monday next, May 5th, and will remain open until Friday, May 16th. It will be housed simultaneously at Castle Bromwich, Birmingham, and at Earl's Court and Olympia, London. With this issue we publish an eight-page supplement descriptive of some of the exhibits at Birmingham. In the article below we have chosen for description some of the more novel and interesting scientific instruments which will be on view at Olympia.

The Sperry Gyroscope Company, Ltd.

A variety of marine and aircraft instruments will be on view on the stand of the Sperry Gyroscope Company, Ltd., Great West Road, Brentford, Middlesex.

FIG. 1—"MINOR" MARINE GYRO COMPASS—SPERRY

Among the marine exhibits is a new instrument, the Sperry "Minor" gyro compass, which is shortly to go into production. The gyro compass is possibly unique among the products of man's ingenuity, in that it is perhaps the only machine which utilises the rotation of the earth. The new instrument, illustrated in Figs. 1 and 2, is stated to differ from previous gyro compasses in being entirely self-contained. The whole equipment is carried in a binnacle of maximum diameter 23in and height 57in, and can be operated with the binnacle completely closed for long periods without attention. It is designed for mounting in the wheelhouse and is provided with a large-scale compass card facing the helmsman and a normal scale card on the opposite side of the binnacle for the use of the officer of the watch. Although the enlarged scale card is only 6in in diameter, its graduations are of size equal to those of a compass card of 30in diameter. The instrument is intended to meet the requirements of owners of small cargo ships, trawlers and large yachts, in which there is frequently insufficient space for fitting more elaborate equipment.

For purpose of exhibition the gyro compass binnacle will be made of Perspex, and the compass will be mounted on a platform continuously rolling 20 deg. to each side of the vertical. Under these conditions the compass works and maintains its indication of true north.

Since in many cases this instrument will be fitted in existing vessels, it is designed for simple installation. In fact, all that is necessary is to secure the binnacle to the deck by means of four bolts, through a deck pad, and to connect leads to the ship's main supply. The instrument can be supplied to suit any d.c. voltage from 20 V upwards.

In the Sperry "Minor" the mounting of the sensitive element is such that there is no pendulous effect from swings of the frequencies met at sea; as a consequence there are no rolling errors. The upper of the two components forming the instrument houses the gyro compass, which includes the north-seeking element and the dial cards. The lower part houses a control panel and amplifier, a motor generator and a portable correction calculator. Space is also provided for a transmission system, if required. The binnacle is supported on four tubes, which also form part of the ventilation system. Air is drawn in through vents at the bottom of the binnacle and passes through the tubes to escape through a vent in the upper cover.

The gyro compass consists essentially of a sensitive element, a phantom ring and an outer member. The sensitive element is that part which is sensitive to the earth's rotation, comprising a rotor, ballistic and vertical ring. The rotor, of bronze, weighs about 11 lb and runs at a speed of 15,000 r.p.m. To reduce the torque to spin the rotor and to reduce heating, the rotor spins in a vacuum, but the maintenance of the vacuum is not essential to the accuracy of the compass.

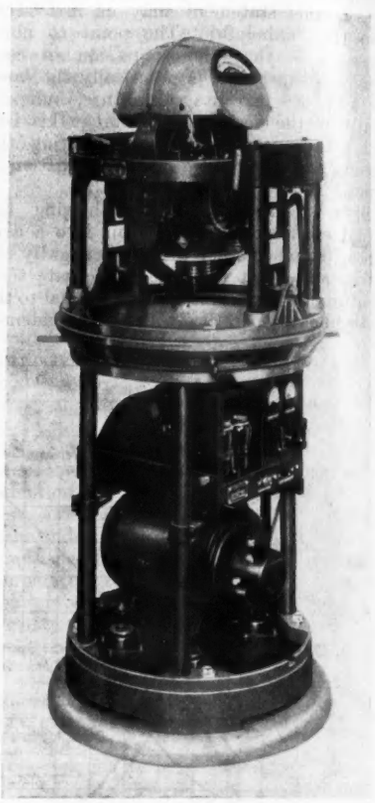


FIG. 2—MARINE GYRO COMPASS WITH COVER REMOVED—SPERRY

A. Gallenkamp and Co., Ltd.

A considerable variety of general laboratory equipment and scientific apparatus can be seen on the stand of A. Gallenkamp and Co., Ltd., 17–19, Sun Street, Finsbury Square, London, E.C.2. The exhibits of more general interest include some examples of a new design of muffle furnace which is suitable for research on heat treatment, hardening and annealing of small parts, heat-treatment of optical glass, ash determination, ignition of precipitates, fusions, &c. Designed to be suitable for a maximum temperature of 1000 deg. Cent., the muffle furnace is electrically heated and incorporates a Gallenkamp-Sunvic control unit.

A typical example of this class of muffle furnace is illustrated in Fig. 3. The casing is built up of Asbestolite panels on a duralumin angle section framework to form a smooth, durable, corrosion-resisting exterior surface. The heating chamber is a translucent silica muffle, wound with high-grade nichrome wire of sufficiently heavy gauge to give long life and rapid heating. The muffle is held in place by refractory insulating

bricks, which are securely anchored inside the case by Asbestolite panels fixed to the duralumin framework. Lagging material is packed inside the case. A 2in diameter flue at the back is formed by a cast aluminium elbow and an aluminium tube fitted with a rotating vane to control the draught.

Two alternative arrangements of door opening are available. The furnace illustrated here (type "S") has a door which is faced with a refractory brick and slides vertically between aluminium runners. A lifting rod with an insulated handle passes through a cast aluminium guide which embodies a clamping screw so that the door can be fixed in any desired position. This arrangement is very useful when making combustion and ash determinations. For convenience a cast aluminium shelf is fitted to the front of the furnace immediately below the door opening. The alternative construction, designated type "L," uses a hinged door faced with a refractory brick and closed by a simple latch fitted with an insulated knob.

The furnace is controlled by a Gallenkamp-Sunvic control unit, flush mounted inside the

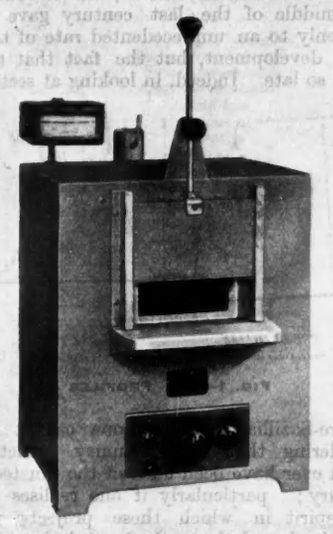


FIG. 3—MUFFLE FURNACE—GALLENKAMP

furnace case. The control unit consists of an energy regulator, a hot wire relay, an indicator light, and a double-pole switch and fuse complete in an enamelled steel case. Among the advantages inherent in this control system are that external resistances are eliminated, that negligible power is dissipated in the control circuit over the entire range and that the operation is independent of voltage variations. When fitted to Gallenkamp muffle furnaces these control units are capable of controlling temperatures to ±10 deg. Cent. over a twenty-four-hour run or to ±5 deg. Cent. over shorter periods. The regulator dial is provided with an arbitrary scale 0–100; although this scale bears no relation to actual furnace temperatures, it can be calibrated by the user to suit the particular furnace to which it is fitted. If automatic temperature control is required, a Gallenkamp thermostat can be fitted as an extra item.

To obtain the maximum operational efficiency the makers recommend the use of a pyrometer, and a suitable 3½in scale instrument with a 6in thermo-couple can be fitted to the furnace, if required, as shown in the accompanying engraving. A further reason for fitting a pyrometer is that, when operating at temperatures approaching the maximum, it is essential to measure the temperature directly, so as to protect the furnace winding against overheating.

The furnace described is made in three sizes with muffle dimensions ranging from 9½in by 6in by 3½in to 22in by 7½in by 5½in. The three sizes have maximum power consumptions of 2000 W, 2800 W and 5000 W respectively, and the muffles can be wound either for 100/110 V or for 200/250 V. Each furnace is supplied complete with 3ft of t.r.s. cable.

W. EDWARDS AND CO. (LONDON), LTD.

For many years W. Edwards and Co. (London), Ltd., Kangley Bridge Road, London, S.E.23, has specialised in the manufacture of vacuum pumps, and amongst the

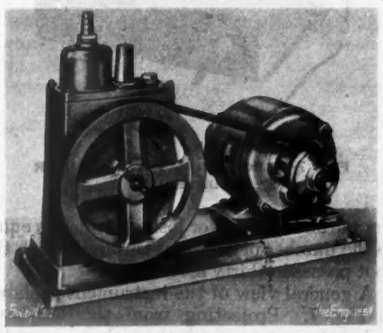


FIG. 4—ROTARY VACUUM PUMP—W. EDWARDS

equipment to be exhibited on its stand is the "Speedivac" series of rotary pumps for the production of high vacua. These pumps, one of which is illustrated in Fig. 4, are simple in design and are strongly built to maintain a high degree of efficiency over long periods. From the diagram in Fig. 5 it will be seen that the pumps consist essentially of a rotor A, in which are two opposed sliding blades held apart by centrally disposed springs B. The rotor is eccentrically mounted in the stator C so that both rotor and stator are in contact over a part of their diameters

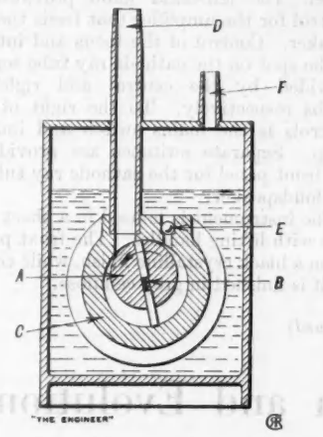


FIG. 5—OPERATION OF VACUUM PUMP—W. EDWARDS

between the inlet port D and the outlet port E. The whole assembly is mounted within a tank and completely submerged in oil. Air drawn into the pump through the inlet port is forced past a non-return valve in the outlet port and leaves the tank through the connection F, which incorporates a baffle to arrest any oil suspended in the outgoing air. A controlled amount of oil is allowed to reach the interior of the pump, where it serves to seal the contacting surfaces and provide lubrication.

Air is exhausted until the pressure at the inlet is reduced to about 0·01 mm Hg., the limit being determined by the effectiveness of the fit of the various parts and the sealing provided by the oil film. It is stated that by using two similar sets connected in series and immersed in the same oil tank low pressures to about 0·00001 mm Hg. may be reached.

For use where the lowest possible pressures and the highest pumping speeds are required the firm has developed a range of mercury diffusion pumps designed to produce an ultimate vacuum of 10^{-6} mm Hg. or below.

In order to provide a small combined compressor and vacuum pump for general work what is known as the "Type IV" unit is being made. In this unit the pump is mounted on a common base with the motor, which is available in two sizes. With the smaller motor of ¼ h.p. an air pressure of 10 lb per square inch is obtainable and with the larger motor of ½ h.p. this pressure is increased

FIG. 6—COMBINED COATING UNIT—W. EDWARDS

to 15 lb per square inch. A vacuum of 24in can be obtained with these little units.

The firm's latest vacuum coating units have been designed to meet the growing industrial and research applications of the important new vacuum techniques of evaporation and cathodic sputtering for the deposition of thin films of metals, many alloys and salts. The general appearance of a combined sputterer and evaporator is illustrated in Fig. 6. In its standard form the evaporator unit alone is suited to the needs of the optical industry for the production of high-quality reflectance films, the deposition of low reflectance films for the so-called "blooming" technique, the deposition of special films for colour camera work, graticule production, &c. There are numerous other applications where normal plating methods are unsuitable or inapplicable.

In the combination unit the vacuum chamber can be either in the form of a "Pyrex" glass bell or a stainless steel chamber provided with inspection windows. A moulded rubber gasket makes a vacuum tight seal between the chamber and the base-

plate. In the nickel-plated steel base-plate is a central exhaust opening connected to the vacuum pumping unit. It is fitted with five metallised ceramic electrodes. Four of these electrodes are for evaporator heaters and one for the high-tension ionic bombardment cleaning system. A vacuum release valve is provided with a fine control needle valve for adjustment of the required gas pressure during bombardment cleaning or sputtering.

The cathodes of the sputtering equipment are supported above the base-plate carrying the work table by two insulated and screened supports, one of which is connected to a metallised ceramic lead-in. The discharge voltage is supplied from an a.c. mains operated d.c. power pack giving an output of 2000 V at 150 mA maximum. The output of the power unit is continuously variable from zero to maximum. A magnetic circuit breaker in the h.t. supply is fitted to prevent excessive discharge currents during the initial cleaning. The necessary control of sputtering pressure and the injection of gases other than air, if desired, is effected by the needle valve of the evaporation unit.

The cathode leads are shrouded to prevent sputtering from unmounted surfaces. A maximum of 150 A at 20 V a.c. can be supplied to any of the four evaporator heaters by means of a selector switch, and the power can be continuously varied from zero to the maximum. The high-voltage supply for the ionic bombardment cleaning apparatus is applied between the cathode base-plate and one insulated terminal to which any desired form of electrode can be attached.

For the production of hard "bloomed" surfaces and certain strongly adherent reflecting surfaces it is desirable to heat or bake the surfaces prior to, during, or after coating, and for this purpose one of two forms of standard chamber heaters can be fitted according to requirements.

Furzehill Laboratories

The apparatus to be exhibited by Furzehill Laboratories, Boreham Wood, Herts, includes an instrument of more than usual interest to watch manufacturers and repairers—an electronic watch timer, designed for the rapid calibration of watches and clocks. In principle, the instrument effects a comparison between the tick of the watch and the frequency of a crystal-controlled oscillator.

Briefly, the crystal-controlled oscillator, with suitable frequency divider circuits, generates a signal of 20 cycles per second, which is accurate to 20 parts in a million, or 1·7 seconds in a day. This signal is applied to a cathode ray tube, causing a spot on the fluorescent screen to trace a circular path twenty times per second. Comparison is brought about by picking up the tick of the watch on a microphone, amplifying the signal and feeding the output signal to the cathode ray tube in such a way as to increase the brilliance of the spot.

Normally the brilliance control is adjusted so that the spot is just less than visible without the tick, and when the tick is being picked up the spot is clearly visible. If the watch is keeping correct time the spot will remain stationary. The spot will move in a circular path, clockwise if the watch is gaining and anti-clockwise if it is losing. To interpret this result quantitatively there is a circular scale graduated in 150 divisions, against which the movement of the spot can be measured. The number of seconds that

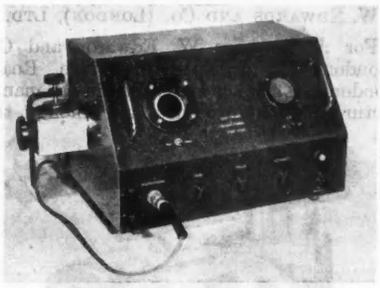


FIG. 7—ELECTRONIC WATCH TIMER—FURZEHILL

the watch is gaining or losing per day is equal to the number of divisions through which the spot passes in thirty seconds.

A general view of the instrument is shown in Fig. 7. Projecting from the left-hand end of the instrument is the pick-up assembly with the microphone lead plugged in to the instrument proper. This assembly can be rotated through 90 deg. and clamped in any intermediate position to allow the accuracy of the watch to be checked in various attitudes. The dial on the left of the front panel contains the graticule, behind which is the screen of the cathode ray tube. Behind the grill on the right of the front panel is a small loudspeaker, which amplifies the tick so that various faults which are characterised by peculiarities in the tick can readily be diagnosed by the operator.

The instrument controls are conveniently disposed on the lower portion of the front panel. The left-hand knob provides gain control for the amplifier that feeds the loudspeaker. Control of the focus and intensity of the spot on the cathode ray tube screen is provided by the central and right-hand knobs respectively. To the right of these controls is the mains switch and indicator lamp. Separate switches are provided on the front panel for the cathode ray tube and the loudspeaker.

The instrument is housed in a sheet metal case with lifting handles. The front panel is given a black crystalline finish, while the case itself is finished in grey cellulose.

(To be continued)

Sazillism: Its Origin and Evolution

By S. LELIAVSKY BEY

No. I

I.—Origin of Sazilly's Method

THE history of dam theory is usually supposed to have begun with the well-known paper on the subject, published by de Sazilly, in the "Annales des Ponts et Chaussées," in 1853. Before Sazilly, the criteria for dam design were based upon external stability only. Safety was required to be ensured against overturning and against sliding on the underlying foundation, irrespective of any consideration concerning the internal stress condition in the block; it was, therefore, only natural that all the older Spanish and French dams, belonging to what we might refer to as the "pre-Sazillian" period, were roughly rectangular or slightly trapezoidal in section (see Fig. 1). Sazilly and his followers introduced a new criterion: the intensity of the unit stress; with the result that, the dam being now visualised as a beam of equal resistance, its width was made gradually diminishing, from the foundation level at which the water pressure and the moment were a maximum, towards the crest level, at which they entirely vanished. It was reported that the first dam designed according to the new principle (Gouffre d'Enfer) represented more than fifty per cent economy as compared with the older designs.

Judging, therefore, by the importance of the invention, one might rather expect Sazilly's name to be better known to the general public, ranking, perhaps, with those of the greatest engineers of his time; that it is not so well known is probably due to the fact that he was partly eclipsed by a number of other innovators, who at about the same time, succeeded in introducing Navier's bending theory (trapezoidal stress diagram) into various other fields of practical engineering applications (metal bridges, railways, &c.).

The points, however, which call for particular stress in reviewing the engineering progress of this period, are not the numerous discoveries and inventions, which towards the middle of the last century gave rise suddenly to an unprecedented rate of technical development, but the fact that they came so late. Indeed, in looking at sections

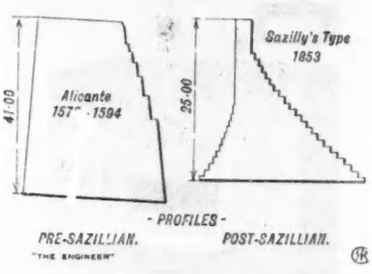


FIG. 1—DAM PROFILES

of pre-Sazillian barrages, one cannot help wondering that such clumsy structures could ever have been built in the nineteenth century; particularly if one realises that the spirit in which these projects were conceived, and the methods of design which were adopted in working them out, were just the same as they had been some two hundred years earlier. Yet, so much had been done during the same period in pure science. The contrast is indeed striking.

II.—Earlier Post-Sazillian Period: Conventional Application of the Method

In the seventies and eighties of the 19th century, dams were commonly designed according to Sazilly's method, allowing a certain amount of tension at the upstream face; the limit of that amount being determined in each case from specific experiments with test-blocks, prepared *ad hoc*. This method of design resulted, of course, in several failures, the most important of which was that of the Bouzey dam, which occurred in 1895. A few months later, Maurice Levy, in a memoir submitted to the French Academy of Sciences, proposed that in order to safeguard stability against uplift, the compressive stress at the upstream face should not be smaller than the hydraulic pressure at the same level. This criterion was, at one time, very popular among French designers, and played an important part in the evolution of Sazilly's principle. It implied that the sub-tangent angle of

the elementary triangular dam-profile was to be increased from $\tan^{-1}\sqrt{1/\nu}$, as it had been according to Rankine's "middle third" law, to $\tan^{-1}\sqrt{1/(\nu-1)}$.

Instead of this Lickfeldt and Link proposed respectively, $\tan^{-1}\sqrt{2/(3\nu-4)}$ and $\tan^{-1}\sqrt{\nu/(\nu^2-n^2)}$ ("Zentralbl. d. Bauverw," 1898, and "Zeitschr. f. Bauw," 1919), but the criteria of Rankine and Levy have remained valid, until the present, as extreme limits of the profiles usually adopted in practice (sub-tangent angle varying from 33 deg. as a minimum to 42 deg. as a maximum).

Present views on the subject may be summarised as tending towards considering Sazilly's trapezoidal stress diagram as a suitable criterion for designing dams under about 150ft or 200ft. Higher works are also supposed to be designed by the same method, but must be checked by means of more advanced analysis.

In regard to abstract theory, Sazilly's solution has from time to time been the subject of considerable discussion. Two lines of thought appear to have mainly been followed, one of them developed from, and centred upon, the idea of "oblique joints," which were substituted in the theoretical analysis for Sazilly's and Delocre's horizontal sections. The other group was responsible for introducing into dam theory the methods of pure mathematical elasticity.

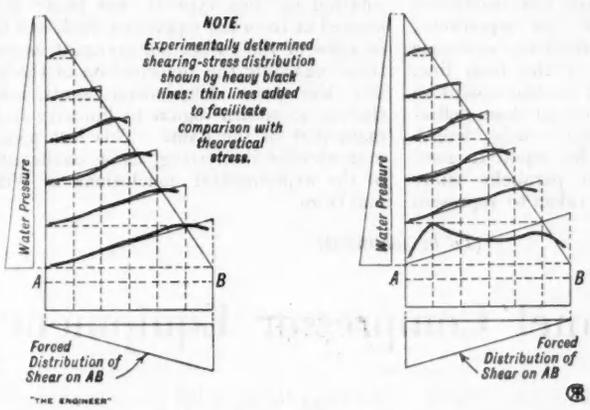

NOTE.
Experimentally determined shearing-stress distribution shown by heavy black lines: thin lines added to facilitate comparison with theoretical stress.
Water Pressure
A
B
Forced Distribution of Shear on AB
"THE ENGINEER"

FIG. 2—MODEL EXPERIMENTS OF WILSON AND GORE

The first school had many disciples. For instance, Bouvier (1875) used inclined joints perpendicular to the direction of the resultant. Guillemain (about 1880), Hétier (1885), and Pelletrau (1897) tended to find the sloping joint corresponding to the maximum normal stress, whilst Clavenad (1887) did the same thing in connection with the shearing stresses. Maurice Levy considered inclined joints normal to the downstream face. Atcherley and Pearson (1905) introduced the conception of a vertical joint, and, finally, Resal, used, as late as 1919, oblique joints perpendicular to the line bisecting the subtangent angle.[1] Inclined stresses developed from Sazilly's postulate were considered also by Professor Unwin, Hummel, Cain, Stoddard, and much later by Holmes[2].

A rather curious fact in connection with all these discussions was pointed out by Mohr (1908). He showed that once the type of curves and equations determining the stress diagrams in one system of joints had been found, or assumed, the stress diagrams in all other systems could directly be determined; that is to say, the whole problem became then statically determinate.[3] He also demonstrated that the trapezium law was the only one from among all the reasonably simple assumptions which did not lead to inconsistent results in so far as stresses in other planes were concerned.

3.—Sazilly's Method and the Theory of Elasticity

Mohr's contribution might, however, be classified more correctly as belonging to the second school of thought of the post-Sazillian period, which tended to verify the postulate of the trapezoidal stress diagrams by the methods of the mathematical theory of elasticity.

Here, again, we must mention Maurice Levy as having initiated a new field of mathematical applications (1898); using the basic differential equations of elasticity (two-dimensional stress problem):

$$dn_y/dy + dt/dx + W = 0$$
$$dn_x/dx + dt/dy = 0$$

he showed that in a dam with an ideal triangular section, subject to its structural weight and to the water pressure (for reservoir-level flush with its apex) all the three main types of stresses (normal stresses on horizontal and vertical planes, n_y and n_x and shearing stresses, $t_x = t_y$) were linear functions of x and y.[4]

He analysed also the effect of an additional depth of water, above the apex-level (negative when below this level). Mitchell[5] and Fillunger[6] extended the analysis to cover the stresses due to the weight of the widening of the masonry work required at the apex of the triangle for supporting the roadway. Secondary stresses due to both these causes were no longer linear.

It was, however, later shown by Kammuller (*loc. cit.*) that these non-linear secondary stress intensities diminished rapidly in importance from the top to the base of the dam.

A marked advance in the theory relating to the mathematical principles underlying the design of dams was thus achieved; there remained, however, another important factor which so far had not been considered: the elastic effect of the foundations. Attention was drawn to this point by the controversy which took place at that time (first decade of this century) between Atcherley and Pearson, on the one hand, and a group of engineers under the leadership of Unwin and Sir Benjamin Baker, on the other. Of particular interest were the experiments of Wilson and Gore, the validity and significance of which have remained unchallenged until the present. In place, however, of the diagrams which are usually produced in referring to the results of these tests, and which are abstracted from a paper on the subject read before the Institution of Civil Engineers, London, in 1908, the author wishes to emphasise the importance of an earlier group of results

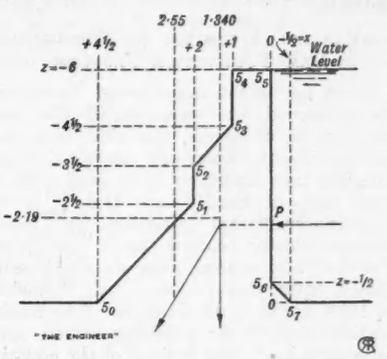


FIG. 3—CONTOUR CHOSEN BY RICHARDSON

obtained by the same authors which was the subject matter of an article published by *Engineering*, in 1905.

Though it constitutes a less spectacular argument against Atcherley's schism, this earlier set of tests, the writer believes, is, nevertheless, as worthy of attention as the more involved later tests. For it supplied valuable evidence substantiating certain significant conclusions concerning dam theory in general and Levy's mathematical confirmation of Sazilly's postulate in particular.

These results are shown in Fig. 2. In the left-hand sketch the artificially applied shear on the under-face of the triangular profile conforms with Levy's and Sazilly's

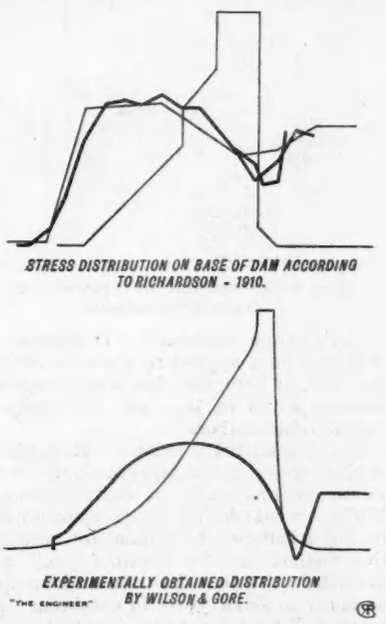

STRESS DISTRIBUTION ON BASE OF DAM ACCORDING TO RICHARDSON - 1910.
EXPERIMENTALLY OBTAINED DISTRIBUTION BY WILSON & GORE.
"THE ENGINEER"

FIG. 4—COMPARATIVE STRESS DIAGRAMS

results. The coincidence of the experimentally obtained shearing-stress diagrams shown in this drawing with the linear stress distribution is a striking proof of the theory. It confirms that in the ideal case of an indefinitely high dam all stresses conform with Sazilly's principle. Even more striking, perhaps, is the second diagram; here the shearing resistances on the foundation were intentionally arranged

[1] See MM. Bouvier's, Hétier's, Pelletrau's, Clavenad's and Resal's articles, all published in Ann. d. Ponts et Ch., in the years quoted. Also: "Rivières et Canaux," by Guillemain's, and "On Some Disregarded Points in the Stability of Masonry Dams," by Atcherley and Pearson, 1905, London.

[2] See Professor Unwin's articles in *Engineering* Vol. LXXIX (1905), p. 513, *et seq.*, Hill's paper in Min. Proc. Inst. Civ. Eng., Vol. CLXXVI (1909); Stoddard's paper, *ibid.*, Vol. CCIII (1916); Cain's and Holme's papers in "Transactions" Am. S.C.E., Vols. LXIV (1909) and XCVIII (1933), respectively.

[3] "Zeitschr. d. Ost. Ing. u. Arch. Ver.," 1908.

[4] *Comptes-Rendus* of the French Academy for the year quoted. Note that the symbols dn/dy, &c., are used throughout in these pages to represent differential co-efficients, usually written dn/dy.

[5] "Proc." Lond. Math. Soc., Vol. XXXII, (1900.)

[6] Ost. Wochenschr. f. d. off. Baudienst, 1913.

in such a way as to be diametrically opposed to those of Sazilly, but, nevertheless, the disturbing influences ceased to be effective in close vicinity to their source. The character of the foundation resistance of a dam is thus a local effect only and this is probably the true reason why practice has supported Sazilly's assumptions for so long a period in the history of dam design methods.

4.—Earlier Attempts at Solving the Dam Foundation Problem

In so far as the foundations themselves are concerned, the stress distribution over the base is, of course, the most important and significant factor, and as this distribution was now shown to have been different from that of Sazilly-Levy theory, it was only natural that attention was henceforward chiefly centred upon this point. The first, and in some sense most successful, attack upon this problem was launched, in 1910, by L. F. Richardson. The mathematical theory of elasticity served again as general basis, but instead of the equation used by Levy the stresses were now expressed in terms of a single scaler F which satisfied the "equation of elastic compatibility"

$$\nabla^4 F = d^4F/dx^4 + 2d^4F/dx^2\,dy^2 + d^4F/dy^4 = 0$$

Thus

$$n_y = d^2F/dx^2 - wy\,;\; n_x = d^2F/dy^2\,;\; t = -d^2F/dx.dy$$

It will be remembered in this connection that the function F was introduced originally by Sir George Airy and is usually known as

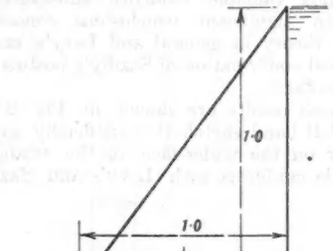


Fig. 5—Comparison of Levy's and Wolf's Assumptions

"Airy's stress function." It appears to have first been applied to dams by Mitchell (*loc. cit.*), in 1910, and has since frequently been employed in this field of enquiry by various other authors.

The characteristic point of Richardson's method was that the equation $\nabla^4 F = 0$ was solved arithmetically in finite differences. While it would be an exaggeration to refer to the calculation of a dam by means of this method as "a life-time job," it is, nevertheless, a fact that its authors spent as much as three years in obtaining "preliminary" figures for the Aswan dam, and this after having simplified the problem by replacing the true profile of the dam by the hieroglyphic scroll reproduced in Fig. 3. The quotation of the price paid for the arithmetical operations, per co-ordinate point, which appears in Richardson's report (n/18 pence, where n is the number of digits), is, therefore, by no means irrelevant; consequently, as far as practical applications go, the method could scarcely be recommended for the everyday routine of designing offices. It, nevertheless, constituted one of the most important steps in the development of the theory of foundation stresses in dams, for it was the earliest and probably most evident demonstration of the agreement existing between the abstract theory of curvilinear stress distribution and the model tests. The conclusion is illustrated in Fig. 4, in which Richardson's results are opposed to those obtained by Wilson and Gore.

How far ahead Richardson's "arithmetical" solution is as compared to the so-called "analytical" methods suggested in connection with the same problem by others may be seen from Karl Wolf's paper on the integration of the equation $\nabla^4 F = 0$ which was published in 1914.[7] In order to deal with the case analytically, drastic simplifications must be introduced. Wolf begins, therefore, by assuming the foundation to be constituted of an altogether rigid substance, which is, of course, wrong, for the materials upon which a gravity dam is built are usually of the same order of elasticity as those used in its construction.

But even this much simplified assumption is found to be too difficult for analytical treatment, which compels Wolf to take a further step in readjusting the conditions of the problem to suit his equations; namely, he is forced to admit the existence of certain deflections on the base line, limiting his requirements to the condition only that the algebraic sum of these deflections, measured over the whole length of that base line, shall be equal to zero. Thus, if in Fig. 5 the parabolic curve with depth "a" can be taken to represent to an exaggerated scale the deflected shape of the base line according to the classical theory of Sazilly-Levy, then the "s" shaped curve would be Wolf's diagram. The advantage so obtained seems open to doubt.

In order to satisfy his assumptions, Wolf introduces a system of imaginary secondary forces applied to the water-face of the dam, determining them in such a way that their algebraic sum is zero and the sum of their squares a minimum. These forces can be visualised as "errors" and must, consequently, be as insignificant as the conditions of the problem and the method used for solving it may possibly allow. Wolf's solution satisfies, also, the equation of elastic compatibility, $\nabla^4 F = 0$, as well as the boundary conditions on the downstream face of the dam. The shear at right angles to the water face is also made zero (as it should obviously be). The result thus arrived at is that the maximum deflection over the base line of the dam is reduced to about twenty-five per cent of that of Levy (see Fig. 5).

The paper, in fact, is an elaborate analytical effort, tending towards a general solution of the problem. The practical conclusions that may be drawn are: that a solution of this type is not likely to be arrived at from the equations used, and that in spite of the rather extravagant assumptions regarding the deformation of the base line, the stress distribution tends, nevertheless, to return again to linearity in the main part of the dam. This last point is undoubtedly interesting, as a confirmation of the experimental conclusions of Wilson and Gore.

(To be continued)

[7] "Zur Integration der Gleichung $\nabla\nabla F = 0 \ldots$" by K. Wolf, Vienna, 1914.

Wind Tunnel Compressor Equipment

UNUSUAL problems of design and construction had to be solved in the provision of machinery for the high-speed wind tunnel of the Royal Aircraft Establishment at Farnborough, Hants. One of the essential requirements was that the plant should be capable of reproducing the many variations of air density encountered by aircraft flying at altitudes ranging from sea level to many thousands of feet. Another was that the air in the tunnel had to be both clean and dry within reasonable limits.

The compressor plant installed was developed and manufactured by Browett Lindley, Ltd., of Coborn Works, Letchworth, Herts. It comprises two combined compressor evacuators and a pilot compressor evacuator. All three sets are two-crank, two-stage vertical installations, the displacement of each of the two main sets being 5000 cubic feet per minute when acting as vacuum pumps or as single-stage compressors and 3300 cubic feet per minute when operating as two-stage machines. The maximum designed power of each set as a compressor is 365 b.h.p. and as an evacuator, 185 b.h.p.

High-Speed Wind Tunnel

Before describing in some detail the compressor equipment, we give a brief account of the wind tunnel itself. A diagrammatic arrangement of the high-speed wind tunnel is given in Fig. 1. It was designed, constructed and erected by Sir William Arrol, Ltd., of Glasgow. The tunnel is mounted in a chamber with cork walls, 6in thick, and brine is circulated through jackets in the walls of the expansion cone and the outer skins of the structure by means of machinery in the compressor room. The overall length of the structure is 130ft and diameter 37ft. The working section is 10ft by 7ft. The total volume is 120,000 cubic feet, and at the normal working temperature of 15 deg. Cent. the weight of air in the tunnel is 4·6 tons. A thirteen-bladed B.T.H. fan, 16ft in diameter, circulates the air. Other points can be followed by reference to the diagram. "Dead space" indicates space outside the circulation system, and when the tunnel is working at atmospheric pressure, observers can be stationed there.

Air is sucked down a central passage by a large fan at one end and is returned *viâ* an annular passage, just inside the outer shell, to the other end. Here it passes into a settling chamber, from which it is again drawn down the central passage.

By having a large contraction ratio from the settling chamber to the first part of the central passage, the air is speeded up, as in a venturi nozzle, and it is here that the model to be tested is mounted.

Motor Generator Set

Power supply is taken from the grid and is transformed down to 6600 V. Since fine control of the fan speed is required over the whole range, a B.T.H. Ward-Leonard set is used. This equipment consists of an a.c. motor of 6600 V., 4800 h.p., driving two d.c. generators, which supply current to two motors. The motors, of 2000 h.p. each, are arranged in tandem to give a direct drive to the fan. They are illustrated on their raised platform in Fig. 2. The motor speed is continuously variable from zero to 950 r.p.m. Control is by a large motor-operated rheostat which varies the fields of the generators and motors. If required, a thyratron automatic control can be switched in, which operates the rheostat to keep the motor speed constant at any pre-set value.

Balance and Recording Equipment

The balance equipment, supplied by the Howard Grubb, Parsons Company, includes a system of linkages to convert the forces and

moments experienced on the aircraft into comparatively small forces at six points on the framework. These forces are measured by remotely controlled steelyards, which record lift, drag, side force, pitching moment, yawing moment, and rolling moment on the model. The model itself is supported on three steel struts.

Since the tunnel is normally under pressure or vacuum, the steelyards are operated by electric motors on the steelyards themselves, which, rotating a screw, move jockey weights along the beams. The point of balance is observed outside the tunnel by measuring the current induced in a search coil attached to the end of each beam. This coil moves in an alternating magnetic field such that the induced current is zero when the beam is in its equilibrium position. The position of the jockey weight when the beam is shown to be balanced is known by use of Selsyn repeater units, the transmitting end of which is coupled to the jockey weight motor. The receiving Selsyn unit operates the hands of the appropriate dial on the observation room balance panel.

By amplifying the current from the search coil and feeding it back to the jockey weight motor, the balance can, when desired, be made to operate automatically. As an illustration of the sensitivity of the balance, the lift component can measure to within $\pm 0 \cdot 1$ lb on static load over a range from -150 lb to $+1300$ lb.

The speed of the air past the model is calculated from the difference in pressure at the settling chamber and at the wall of the tunnel near the model. This pressure difference is measured by connecting the two pressures to respective pots of mercury which have a common connection in the mercury. Any difference in pressures will displace a proportionate amount of mercury from one pot to the other. The amount displaced is found by weighing the pots on an automatic recording steelyard similar in principle to those described above. The movement of the recording Selsyn is calibrated to indicate the pressure difference in inches of water.

The outer shell, return circuit and wall of the central passage are provided with windows set in line so that the model, suitably illuminated, is visible from the observation room during the test. In addition to the balance panel, Bowden gauges and a corrected barometric gauge are provided to record the tunnel pressure. Banks of alcohol manometers are available when required for determination of surface pressures on the model. All recording apparatus can be photographed.

Compressor Specification and Requirements

The Air Ministry required equipment to produce a range of pressures varying from 1·5 lb to 60 lb per square inch absolute, corresponding to the range from 0·1 to 4·0 atmospheres. The time allowed for evacuation to 0·1 atmosphere was one hour, and to a compression of 3 atmospheres gauge it was three hours.

To control the density it was specified that an automatic constant pressure control be embodied in the system, capable of maintaining the pressures or vacuums to within a variation of 0·1 per cent from any predetermined absolute pressure within the range specified, assuming the leakage of air from the tunnel to be about 10 per cent of the capacity of the main unit.

The design involved a compressor for the pressures above atmosphere which, to be volumetrically efficient, meant both a single-stage and a two-stage machine, and this in itself was a problem for the compressor designer. The requirements for the variable absolute pressures or vacua were even more stringent for the evacuator or vacuum pump, and also involved the use of valves suitable for the high vacua.

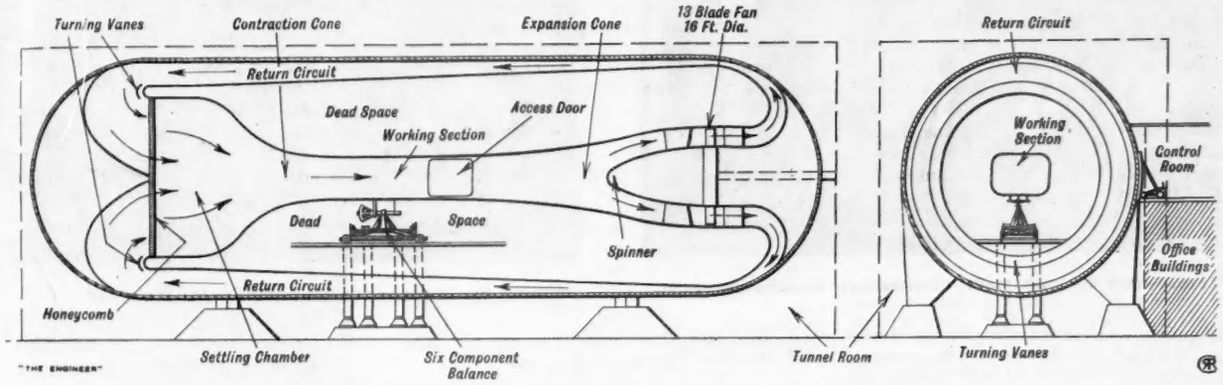


FIG. 1—DIAGRAMMATIC ARRANGEMENT OF HIGH-SPEED WIND TUNNEL

It was evident that four units could have been offered, and at the best two machines for all the duties, but the firm had anticipated the combined compressor-evacuator, and so was in a position to offer a machine capable of performing both duties as economically as four separate units. In addition to being a combined compressor-evacuator, with valves suitable for the two duties, it fulfilled the functions of a single and a two-stage machine, and changed automatically such stages to suit the requirements in the tunnel. This ingenious development saved both valves and the labour which would have been required if such changes had been done by hand in the usual manner.

Main Compressors

A view of one of the main compressor-evacuator sets is reproduced in Fig. 3. These machines are designated by the makers as "Type 8A," and have a bore of 29in and stroke of 13in. They are designed to run at 333 r.p.m. and are mounted on standard Browett Lindley frames. Cylinders are of equal diameter, and have been modified so as to suit the cycle for both pressure and vacuum, the intake valves being suitable for the highest pressure and the lowest vacuum specified.

The machine is double-acting, with two vertical enclosed cylinders, and is controlled by the firm's design of unloading mechanism. This system consists of two parts—a relay valve and an air inlet governor or unloading valve. Pressure air passing through a filter acts under a small piston in the relay valve, which is weight-loaded to the predetermined pressure of operation. The lifting of this piston admits air through small ports beneath another piston, which closes the unloading valve. When pressure drops, this action is reversed and the valve opens. A solenoid fitted to the top of the valve automatically unloads the compressor when the driving motor is started. This device takes the place of the usual hand-operated screw and nut unloader for starting.

A sectional view of one of the sets is reproduced in Fig. 4. The valve chests are divided and No. 1 cylinder, at the fly-wheel end, has its valve chest so arranged that the top and bottom cylinders are separate, each being able to draw in a charge independently of the other, but both discharging to a common chamber. No. 2 cylinder is similarly divided, but is provided with two intake and two discharge pipes. During single-stage compression, up to 25 lb gauge pressure, three cylinders are in operation, the fourth being unloaded and idling. When two-stage operation is required, for the higher pressures, the top half of No. 2 cylinder acts as the second stage.

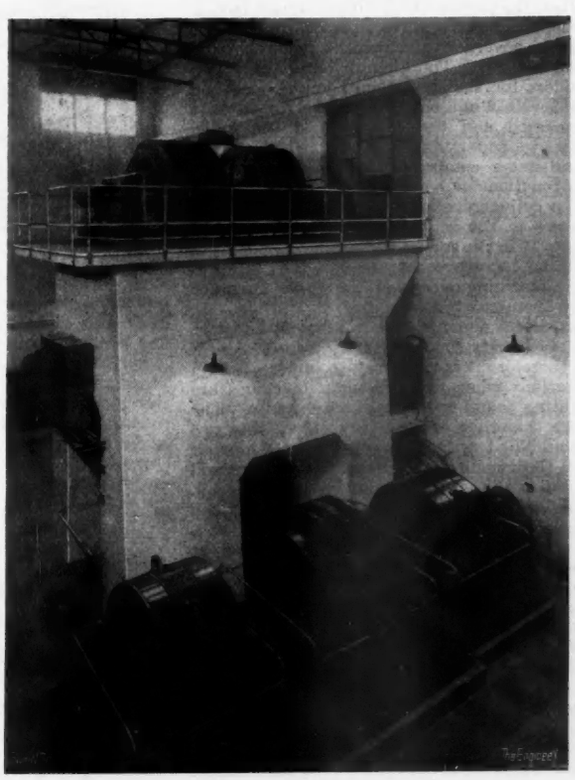


FIG. 2—MAIN DRIVING MOTORS

Lubrication of the cylinders is mechanical, by means of a pump delivering oil to points on the cylinder walls through pipes and non-return

valves. Flow is controlled to about one drop per minute, and it is stated that oil contamination of the air in the tunnel does not occur with this quantity. All intercoolers, aftercoolers and the intake governors are fitted with solenoids. The excitation of the solenoids is connected with the starter stops so that the governor valves close immediately the starter is operated, and open when the starter is on the last stop and the motor has run up to speed.

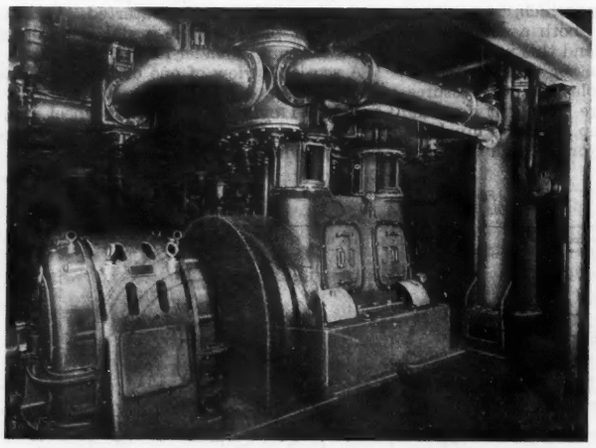


FIG. 3—ONE OF THE MAIN COMPRESSOR-EVACUATOR SETS

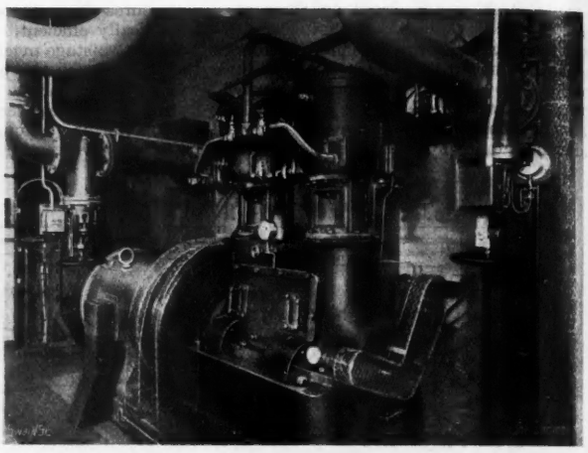


FIG. 5—PILOT COMPRESSOR-EVACUATOR SET

certain points in the pipe system are fitted with automatic taps for condensed vapour drainage, thereby avoiding the need of manual attention to this duty.

OPERATION OF PLANT

For compression pressures below 25 lb. per square inch the cylinders in commission are No. 1 top and bottom and No. 2 bottom cylinder. The three cylinders draw air through filters and discharge through an intercooler to the top No. 2 cylinder in which it passes the intake and discharge valves by virtue of its own pressure, there being no compression work done in this cylinder.

When the pressure of 25 lb per square inch is reached, the relay valve operates and closes an intake governor valve, which cuts out bottom cylinder No. 1. The air now enters only two cylinders for the first-stage compression—top cylinder No. 1 and bottom cylinder No. 2. It is compressed and then passes, *vid* the intercooler, to top cylinder No. 2, which is the second-stage compression. The compressor then functions as a normal two-stage machine with a cylinder volume ratio of 2 to 1, and the pressure in the intercooler drops to approximately 16 lb per square inch. The change from single to two-stage compression thus is automatic, changing over when the intake governor valve operates.

Air filters and air coolers are only efficient to the capacity for which they were designed, and therefore it is necessary to impose certain limitations when the two main machines are operating together as single-stage units. The intake governor valves controlling the two bottom No. 1 cylinders must be closed so that when the machines operate together there will be four and not six cylinders in operation. Therefore the two governor valves are fitted with solenoids which come into action and close the valves when the compressor motors are put into circuit, thus making the flow or air capacity safe for the filter or cooler. The ratio as compared with one machine operating is 4 to 3, or 33 per cent increase in output.

When the sets are operating as evacuators for low vacua, there are three cylinders pumping—top and bottom No. 1 and bottom No. 2. These discharge *vid* the intercooler through top cylinder No. 2, passing through the intake and discharge valves without doing any work. When the vacuum drops to 0·3 atmosphere absolute pressure the machine becomes a two-stage vacuum pump with a volume ratio of 3 to 1. Since the filter and the cooler do not function for their respective duties, there is no volume restriction for the machines.

As it is desirable for the electrical equipment to start the machines unloaded, all intake governor valves must be closed before starting and in order to make this operation automatic the worm gear lifts the first and second-stage intake valves on the bottom cylinders.

PILOT COMPRESSOR-EVACUATOR

The pilot compressor-evacuator set (Fig. 5) is the firm's standard "Type 5A" compressor, similar in construction to the larger main sets, but with a first-stage cylinder bore of 16½in and with a second-stage bore of 10in. The stroke is 7in, speed 415 r.p.m., and displacement 720 cubic feet per minute. It is fitted with gear to permit it to be run at either full or half capacity. For 50 per cent load a hand-operated

The set has intake unloading gear similar to that on the main sets operated through a relay by the predetermined pressure in the tunnel. This pilot unit, with its simple control gear, has, we understand, proved successful in controlling the pressure in the tunnel. Of course, the large capacity of the tunnel and the fact that leakage for any given pressure is

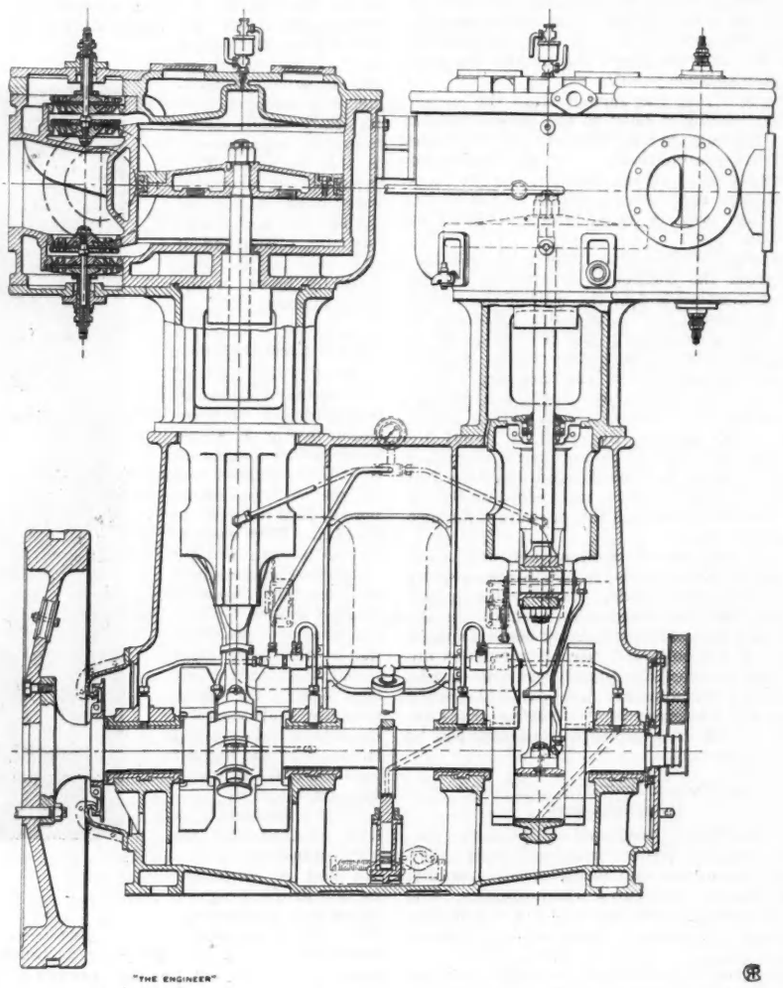


FIG. 4—LONGITUDINAL SECTION THROUGH COMPRESSOR-EVACUATOR

constant helped in making accurate control relatively simple.

Dryer and Filter

The purpose of the dryer is to extract the moisture from the air before it enters the tunnel. This apparatus, supplied by J. and E. Hall, Ltd., Dartford, is a standard refrigerating plant and consists of ammonia compressors with the usual condensers and evaporators which cool brine. The brine in turn, through the dryer, cools the air delivered by the compressors. The air can be cooled to minus 18 deg. Cent., and

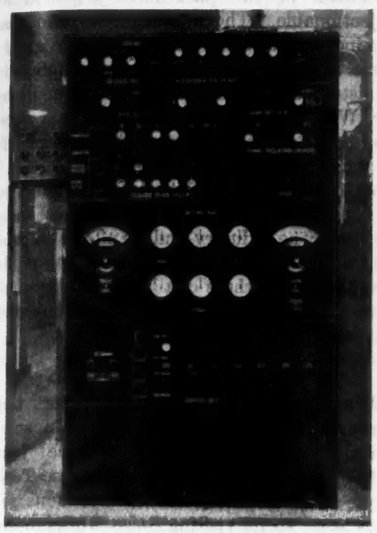


FIG. 6—STATION CONTROL PANEL

such cooling freezes the vapour moisture in the air and leaves it sufficiently dry for the tunnel experiments. The dryer itself is a standard type of cooler, with brine passing inside and air passing outside the tubes.

A "Ventex" air filter, supplied by Ozonair, Ltd., London, is used to extract dust and foreign matter from the air before it enters the compressor cylinders. The principle of construction is that of a large number of corrugated plates

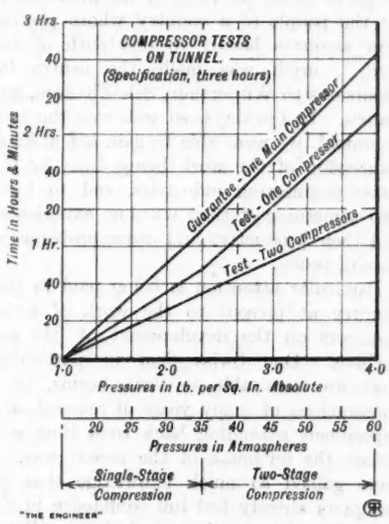


FIG. 7—RELATION BETWEEN TIME AND TUNNEL PRESSURE

spaced uniformly in a frame holder; thus a large surface is exposed to the passage of the air. The complete frame is dipped in a viscous fluid and the air in passing between the corrugated plates is buffeted from side to side. The solid particles of dirt are retained on the sticky surfaces of the plates. The coating fluid cannot flow and there is therefore no risk of it being drawn off the plates even at high velocities, so we understand.

Electrical and Control Gear

Each of the two main compressors is driven by an E.E.C. 400 b.h.p. protected type synchronous induction motor, operating at unity power factor. Brookhirst control gear is fitted. The pilot compressor is driven by an E.E.C. 80 b.h.p. slip-ring induction motor, operating at 410/428 r.p.m., and controlled by Allen West gear.

The station control panel (Fig. 6) comprises gear to make the operation of the plant foolproof, by means of a system of coloured lights, solenoids, cut-outs, and alarms.

A simple mechanism is fitted to each valve or main unit concerned, so that when the compressor is "on compression," a switch is operated and a corresponding red light is shown. When the whole of the pipe system has been set for compression, there is a series of red lights, and a master red light on the panel with an alarm indicating all is in order. At the same time, a master red light is illuminated on the main control panel in the observation room. A similar system is employed for a vacuum test, but in this case the lights are yellow. The panel also indicates air pressures at various points in the compressor-evacuators and controls the dryer plant.

The pipe arrangement has a minimum of change-over valves and the contact switches

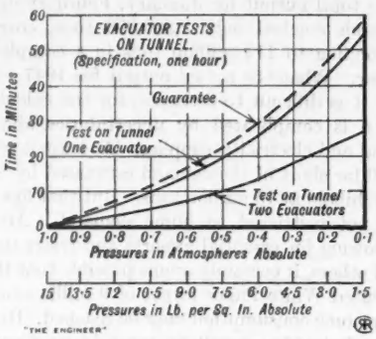


FIG. 8—RELATION BETWEEN TIME AND TUNNEL VACUUM

to operate the system of coloured lights are simple devices operated by a screw mechanism when the change-over valve is fully open.

Test Results

The main machine, when working as a compressor, was guaranteed to bring the pressure in the tunnel up to 60 lb per square inch in three hours. As an evacuator it was guaranteed to evacuate to 0·1 atmosphere in one hour. These times were easily achieved on test, and could have been considerably improved upon, if necessary, by using the stand-by compressor during compression trials and both main sets during evacuation trials. The evacuation time could have been reduced to under half an hour. Curves reproduced in Figs. 7 and 8 give the test results for compression and evacuation respectively.

The Institute of Navigation

In a Journal note of March 14th, we outlined the proposals made to form an Institute of Navigation, which would unite in a scientific body all those within the British Empire who are concerned with or are interested in the science of navigation. The inaugural meeting took place on March 12th, in the Council Chamber of Lloyd's Register of Shipping, and a representative Steering Committee was then appointed. This Committee was authorised by the unanimous vote of the meeting to proceed with the formation and registration of the Institute and the selection of provisional members of the Council. The Royal Geographical Society has generously provided the new Institute with accommodation and facilities, which include the use of its lecture theatre for its meetings. It is now possible to announce that the Astronomer Royal, Sir Harold Spencer Jones, Sc.D., F.R.S., has accepted nomination as President of the Institute, and Air Chief Marshal Sir John Slessor, K.C.B., and Sir Robert Watson Watt, C.B., LL.D., F.R.S., as Vice-Presidents. Provision has been made for the creation of five classes of membership of the Institute, including Honorary Members, Fellows, Members, Student-Members, and Corporate Members. A limited number of Life Memberships in the initial stage are also offered. It is the intention of the Institute to develop the fields of research and education and to maintain close liaison with other organisations, such as the Institute of Navigation of America. It is intended to publish a periodical journal and to provide a library of navigational works. Further information can be obtained from the Secretary of the Institute of Navigation, c/o. The Royal Geographical Society, Kensington Gore, S.W.7.

20,000-kW Swiss Gas Turbine Power Station

One of the larger Swiss electricity companies, the Nordostschweizerische Kraftwerke A.G., has decided to erect a new thermal power station at Weinfelden, in the Canton of Thurgovie, in order to supplement the winter electric energy supplied by the existing hydro-electric plant. The new station is to be equipped with a 20,000-kW gas turbine driven generating unit, which will be designed and constructed by Sulzer Brothers, Ltd., of Winterthur. It will operate on the special cycle developed by the firm, and will drive a 25,000-kVA alternator. The oil fuel tanks for the station will have a designed capacity corresponding to a production of 60,000,000 kWh. The commencement of service with the new generating plant is planned for the winter of 1949–50. At a later date we hope to be able to publish a comprehensive technical description of this important gas turbine installation. It will be remembered that in our issue of January 3rd last, we described the special Sulzer gas turbine cycle, and published photographs of the combustion chamber, recuperator and the combustion testing plant.

The Jubilee of the Electron

It is announced that the Institute of Physics and the Physical Society, in collaboration with the Institution of Electrical Engineers, is arranging to mark the jubilee of the electron by a series of lectures and other functions, to be held in London on Thursday and Friday, September 25th and 26th next. An exhibition demonstrating the great influence this discovery in pure physics has had on the life of the community will be opened at the Science Museum, South Kensington, on Friday, September 26th, and will remain open for about three months. Fifty years ago, on April 30, 1897, Professor J. J. Thomson, later Sir Joseph Thomson, at an evening discourse at the Royal Institution, made the first public announcement of the existence of the electron, and the first approximate estimate of its mass. Cathode rays had already been extensively studied in many laboratories for the previous fifteen or twenty years, and their peculiar properties widely discussed. It was Thomson's genius which enabled him to unravel the confusing and almost contradictory clues which the experiments afforded as to the nature of the phenomenon. He grasped what was important and secondary in the evidence, and made the final experiment which demonstrated beyond all doubt that the cathode rays consisted of negatively charged particles, all alike and all much smaller than the smallest particle hitherto known to science, the atom of hydrogen. In the same discourse Thomson foreshadowed the electron theory of matter, which has dominated physical research for the last fifty years. To Thomson the world owes much, not merely for the original discovery which could not have been long delayed, but still more for the brilliancy with which he continued to lead the researches of the succeeding twenty years and the selfless devotion he gave to the training of the men who were to follow him.

THE ENGINEER

MAY 2, 1947

VOL. CLXXXIII No. 4762

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

For Subscription Rates, see page 2 of Advertisements.

THE IRON AND STEEL BOARD

THE information given by Sir Archibald Forbes earlier this week about the work of the Iron and Steel Board since it was set up last September contained little if any material of particular importance. Sir Archibald was silent upon the relations that exist between the Board and the Iron and Steel Federation, and nothing emerged from the conference to show in what way the creation and the actions of the Board may have influenced the course of development of the Federation's modernisation plans. It was understood at the time when the Board was set up that the Federation's great £168-million plan of development during the course of the next seven and a half years would be examined. At the recent conference it was confirmed that "the Board accepts the aim of the plan in relation to overall capacity" and "also accepts the broad distribution of capacity as set out in the plan." But Sir Archibald did not commit himself to details of any changes that may have been thought advisable. It is, however, satisfactory to note, as readers will see from the report we print on another page of Sir Archibald's speech, that already about one-half, in terms of value, of the schemes proposed by the Federation has been generally approved and about two-thirds of that number approved in complete detail, and that work has already begun on a majority of the latter. Apart from a reference to the fact that "any general plan formulated at a particular point of time is part of a continuing process and would normally be followed by further proposals when those contained in it were nearing completion," nothing was said about the existence of any further plans amplifying those put forward by the Federation. Action is, however, being taken to originate plans more definite than were contained in the 1946 White Paper for the modernisation and re-equipment of the foundry iron and iron-foundry industries.

Perhaps the more interesting references in Sir Archibald's speech were those relating to the productive capacity of the industry. It was confidently hoped earlier this year that the industry would produce 13 million ingot tons of steel in 1947. As a consequence of the fuel crisis and the continuing shortage of coal it is clearly now impossible that such an output can be reached. It is, indeed, very doubtful whether the output for 1947 will be able to reach a level not far below that of 1946 at 12¾ million tons, as suggested in the Economic Survey for 1947. For at one stage of the fuel crisis output fell to a rate equal to no more than 10 million tons per year and the total output for January, February and March reached only 2,800,000 tons, corresponding to 11½ million tons in a complete year. What the actual output for 1947 will be it is difficult to estimate, for the calculation is complicated by uncertainties about coal and electricity supplies. At least it will fall far short of the demand estimated by Sir Archibald at 15 million tons. But that figure is not restricted to home demand. After allowing for essential exports and restricting all others, it certainly seems possible that the limited White Paper target of 9 million tons for home consumption may be reached. How far that amount will go towards meeting a home demand inflated by the shortage of other materials remains to be seen. The Government's policy, as announced recently by Mr. Wilmot, is to restrict priorities "to programmes directly contributing to the expansion of fuel and power resources." Other users will have to be content, no doubt, with what is left over. In estimating the output of the steel industry in 1947 allowance has, too, to be made for the effect during the year of conversions to oil firing. The extent of the economy in coal consumption that it is hoped to effect is rather remarkable. The saving by the end of 1947 is likely to amount to a rate of 1,800,000 tons of coal per year. It may perhaps be added that it seems equally remarkable in a country so richly endowed with coal measures as ours that such a conversion should be necessary, and that, when the price levels of oil and coal reach a stability it may well be found that the economic justification for the conversion is dubious. A similar comment may be applied to the use of electric furnaces for the manufacture of ordinary carbon steel. Before the war an expression much stronger than Sir Archibald's remark that it "was not in general economic" would have been called for.

If it did nothing else, Monday's conference did at least confirm that the Iron and Steel Board is pressing forward the work of modernising the steel plants of this country. Since, however, reference to political or quasi-political questions was specifically banned, it was not possible to discover what effect the attitude of the Government is having upon that work. For an aura of doubt still surrounds the future of iron and steel production. The Government has not shown itself content to have set up a controlling body for the industry, upon which both management and labour are represented. It remains uncertain whether it is even content to see how that Board succeeds in its task and how far it will be able in the future to suppress those activities of the industry that Socialists in the past have regarded as objectionable. The intention to nationalise the industry at some unspecified date and to some unspecified degree remains implicit in Ministers' statements, such as that made by Mr. Wilmot last Monday in reply to a question that "no legislation on this subject will be introduced during the present session." How far this uncertainty may be affecting the interest and enthusiasm of those concerned in the industry and its efforts to raise capital for new construction, may be doubtful. But there can be no doubt whatever that any effects there may be must necessarily be deleterious.

A VISIT TO SWITZERLAND

WE recently returned from a short tour through Switzerland, organised for a small party of editors of British technical journals by the Union Suisse de la Presse Technique et Professionnelle. A strenuous few days were spent visiting Swiss works manufacturing a variety of articles, ranging from sewing machines of a new modern design, to heavy electrical plant, machine tools, hydraulic machinery, electric locomotives, oil engines, and, of course, gas turbines. The tour took us to Geneva, Basle and Zurich. At Basle we were able to spend a few hours in the halls of the Swiss Fair, to see a very fine display of machine tools of Swiss manufacture, and to come away somewhat astonished by the remarkable range of other products of all kinds made by the people of a country whose population amounts hardly to one-tenth of our own. urich was made the centre for excursions to Winterthur, Schaffhausen, and Baden. In ten days, so well was the tour organised, we were able to gain a first-hand impression of the work being done by the Swiss engineering industries, and to learn also something of their wartime experiences and their productive and other problems in time of peace.

Particular attention is being paid in this country at present to the work of Swiss engineers on the development of the gas turbine. One Swiss firm in particular, that we were able to visit, seems, as a consequence of many years of research and experiment extending back to a time well before the outbreak of the recent war, to have gained so much knowledge that its designers already feel full confidence in the reliability of its products and that predicted performance figures of any projected plant will be attained. But other Swiss firms, too, are well advanced. It is interesting, also, to note how in each of the firms manufacturing gas turbine plant the problems in the design and operation of that new prime mover are being tackled in differing ways. The firm of Brown Boveri, for instance, has developed and continues to

develop open-cycle plant. Escher-Wyss Engineering Works, Ltd., presses strongly the advantages of the closed-cycle system. Sulzer Brothers, Ltd., has developed a semi-closed system combining to some extent the advantages of each of the others and has been experimenting, too, with gas generation in the free-piston compressor. Ateliers de Constructions Oerlikon, unlike the others, prefers the centrifugal compressor. The respective merits of these competing systems remain as yet undecided. Indeed, though much theoretical work has been done on the merits of differing cycles and of differing arrangements of the various compressor, heat exchanger, and gas turbine units the test of practical experience has only been undergone by relatively few machines. As we have said, any reference to Swiss industry at the present time necessarily throws the thoughts of British engineers to the gas turbine. But it would be a very bad mistake to suppose that it is the only device under development in Switzerland that stimulates the interest of the technical visitor. Several of the firms we visited—indeed, nearly all of them—had plants, machines, or tools undergoing trials, or in an earlier stage of development that we were permitted to see. In particular, the memory sticks in our mind of the latest electric locomotive, so designed that it develops nearly twice the power per unit weight of earlier locomotives still running on the Swiss railways; of an ingenious and novel tramcar drive, possibly adaptable for other purposes; of a very fine precision machine tool under development in Geneva and of a horizontal boring and milling machine under construction in Schaffhausen; of a model of the Brown Boveri "Komprex"; of a demonstration of the use of an Escher-Wyss variable pitch marine propeller; and of an oil engine of surprising capabilities under test at Sulzers. In due course, as and when the firms concerned feel that the moment is opportune, we shall hope to publish descriptions of these and of other devices that we were shown.

Though opportunities in a strenuous tour were infrequent, we did not wholly neglect to enquire about matters which, though not strictly technical, are necessarily of interest to engineers on the human side. For labour relations in Switzerland must always interest the British people if only because the Swiss people, like our own, have the principles of liberty and democracy deeply rooted in their history. Moreover, the further parallel can be drawn between the two nations that both, despite their wholly different geographical situations, are dependent for prosperity upon exports, a fact that inevitably has a deep and important influence upon the wage structure. It is interesting to find that in Switzerland, as in Britain, the attempt is being made to resolve the conflict between capital and labour by convincing both sides that it is their common interest to combine. The Swiss method is to create "corporations," the aim of which "is to realise in the framework of the common profession, collaboration between employers and workers with a view to safeguarding the moral and social interests of all those belonging to the same professional group." Contact between Swiss and British engineers was almost lost during the war. We say almost, because, despite the efforts of our enemies, some munitions and tools made in Switzerland did, in fact, during the war years, find their way to this country. It is, we believe, an advantage that contact should be fully regained so that there may return that stimulating flow of ideas that has had in the past and will have again in the future such beneficial reactions on engineering techniques and practical developments in both countries.

The Institution of Mechanical Engineers

At a general meeting of the Institution of Mechanical Engineers, on Friday, April 25, 1947, the 1947 James Watt International Medal was presented, on the nomination of the Swiss Society of Engineers and Architects, to Professor Stepan Timoshenko.

Dr. H. J. Gough, making the citation, said that Timoshenko's contributions to engineering science as a brilliant and inspired teacher were sufficient to merit the highest honours. A great number of engineers of many nationalities had been privileged to be his personal students. His influence on engineering education, however, had made itself felt in much wider circles, and it was perhaps during his professorship at Ann Arbour, Michigan, that he did his supreme work in this field. Many fellowship students came from all over the world to complete their training with him. His Summer Symposium in Applied Mechanics became famous. He played a notable part in founding the Applied Mechanics Division of the American Society of Mechanical Engineers and its *Journal of Applied Mechanics*, and he had been prominent as an organiser, contributor and participant in the International Congresses of Applied Mechanics. Probably more than any other man he had influenced and guided the teaching of applied mathematics in the United States of America. From his untiring pen there had come a succession of about twenty books on the theory of elasticity, dynamics, stability, vibrations, structures, strength of materials and other subjects. Those works, noted for the penetrating insight, high quality and creative ability displayed, and always directed to emphasise the practical bearing of the principles they expounded, had become standard engineering textbooks. Timoshenko's books formed a bridge between the often abstruse presentation of classical theory by pure mathematicians and the solution of practical problems encountered in design.

Apart from Timoshenko's services to engineering in the fields of academic work and authorship, he had achieved international fame and renown as a research worker and an investigator. He was the author of nearly one hundred major papers, contributed to learned societies and technical institutions and covering a field of inquiry of an amazing scope. Throughout all his work ran the primary theme of the development of mathematical analysis as a practical engineering tool, but, wherever possible, Timoshenko had always endeavoured to obtain experimental verification of the results of analytical research. His fundamental contributions, which were too many to mention in detail, included studies of problems relating to engine and machine components, structural members and foundations, steam turbines, ships, railways and bridges, and many aspects of the strength of materials had also received his attention. In the realm of pure technique, Timoshenko's development of the Rayleigh-Ritz energy method constituted a milestone in the progress of stress analysis. His original and early treatment of impacts on elastic bars, on forced vibrations and on the stability of plates and shells pointed the way to the solution of such basic problems as the forced vibrations of bridges, torsional oscillation of crankshafts and the strength and stiffness of modern aircraft construction. In much of Timoshenko's researches there was to be seen not only the brilliant investigator, but also the true pioneer.

In their reverent memory of James Watt, engineers thought of the pioneer of the application of science to the development of the steam engine and to engineering in general. In Stepan Prokofievitch Timoshenko they recognised a scientist and technician of international repute, who had greatly assisted the progress of engineering by brilliant researches and investigations and by inspired teaching and who was eminently worthy of the highest honour which the Institution could bestow, the James Watt International Medal.

After the presentation Professor Timoshenko gave a lecture on "Stress Concentration and Fatigue Failures."

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LOCOMOTIVE VALVE GEARS

SIR,—My views on the respective merits of the Walschaerts and Stephenson gears were given in THE ENGINEER of January 24th, but in consequence of the number of exchanges he has had with Dr. Tuplin on this subject, Mr. K. N, Harris has suggested that my further remarks might be of assistance, and I will endeavour to straighten things out by defining the issues.

All locomotive valve gears in common use, operating piston valves, are fundamentally the same, in that the variable travel and angular advance of the valve are given by the combination of the motion derived from two cranks, eccentrics or their equivalent, set at an angle to one another. By varying the proportion which each crank contributes to the combined movement, travel and angular advance of the valve can be regulated. In the mid-gear position the motion derived from the combination is in phase with the main driving crank (in the case of valves with inside admission).

The mechanisms by which this combination is brought about are many and the choice of the gear to be adopted is largely influenced by mechanical considerations and general convenience of the layout in the design of the engine, the question of maintenance and accessibility, &c. Thus, we have the Walschaerts and Baker gears with the equivalent of cranks at 90 deg. to one another; the Southern, Joy and Bulleid gears derived by splitting the motion of one crank into its horizontal and vertical components, so obtaining the 90 deg. difference in angle. In the case of the Gooch (stationary link motion) or the Stephenson (shifting link motion) the cranks are in the region of 120 deg. to one another.

With the exception of the latter gear, the amount of opening of the valve when the piston is at the end of its stroke is a constant quantity from full gear to mid-gear and they are said to have a constant lead. The method of variation of travel in the case of the Stephenson gear involves a partial rotation of the mechanism about the axle. The degree of angular movement resulting depends on the length of the rods and the distance apart of their connections to the link, being greater with short rods and wide centres. A result of this rotation is to vary the amount by which the valve is opened at the end of the piston stroke as between full and mid-gear, the degree of variation increasing with the angular movement about the axle, and the motion is said to have variable lead. With the usual setting of the eccentrics, known as "for open rods," lead in mid-gear is larger than in full gear. A smaller variation in lead opening can be brought about by combining the Gooch and Stephenson gears, by raising the valve rod simultaneously with the lowering of the link, or vice versa, so reducing the angle of rotation necessary. This gear is known as the Allan (or straight link).

Thus, we see that variable lead is a controllable quantity and can be adjusted, in designing the gear, at the discretion of the designer. If, however, the increased amount of lead opening between full gear and that at running cut-off is considered excessive all that is necessary is to increase the lap at the expense of lead. The result of doing this may be to produce negative lead in full gear, *i.e.*, the valve opens after the piston has passed the dead centre.

In the case of gears with constant lead the amount of lead opening must be a compromise. If it is adequate for running cut-off, it is excessive in full gear, so that starting and acceleration are affected. On the other hand, a lead satisfactory for slow speed results in inadequate port opening at short cut-off. It might be urged from a theoretical standpoint that the angle at which pre-admission occurs in full gear is so small that the negative turning moment due to steam pressure on the piston is negligible, but practical considerations step in. The type of piston valve now in general use has a solid head with a number of narrow rings. It is steam-tight enough as regards leakage of live steam to exhaust but not as to leakage from steam chest to cylinder, since the head has to be made about $^1/_{32}$in smaller than the bore of the valve liner: on a 10in dia. this is equivalent to quite a large hole, and therefore during the starting period premature admission occurs much earlier than nominal opening to steam and at a large crank angle. With increase of speed and rise in compression this leakage decreases and becomes of small consequence.

The leakage is largest where the valve head is used as the cut-off edge. To try to reduce this leakage some railways transfer the cut-off edge to the side of the first ring, cutting down the groove in the head to expose the ring and allow some passage for steam admission. This practice leads to greater side wear of rings in grooves and the projecting portion of the head offers some obstruction to a clear port opening. Where negative lead is provided, this premature admission is delayed until the piston is at or near the end of its stroke, and therefore engines with this feature are prompt starters.

The G.W.R. policy of building standard types of two-cylinder engines with Stephenson gear has continued for forty-five years under Messrs. Churchward, Collett and Hawksworth, material evidence of sound design and adequate performance.

Such engines are used for all purposes, but, additionally, for the specialised duty of running long-distance, high-speed trains a few four-cylinder engines are provided because experience has shown that they are better suited to the particular work. If they happen to have a Walschaerts gear it is as much from necessity as choice, owing to space limitations.

The G.W.R. is in the happy position of having the works and running departments under one head. Those operating the locomotive stock therefore stand the best possible chance of getting the engines they want. Elsewhere there is a tendency to design engines with a view to cheapness in construction, maintenance and renewal, too much from the "works" angle, and the running man gets "just what the doctor ordered." If now and again the rings are fast in a solid head piston valve and it takes hours, or even days, of the shed fitters' time to extract the valve for examination, well—it's just too bad!

H. Holcroft.

Chipstead, Surrey, April 26th.

LOCOMOTIVE VALVE GEARS

Sir,—The desirability of accuracy in technical discussion is emphasised by Dr. W. A. Tuplin in a letter published in your issue of March 28th in reply to a letter from Mr. K. N. Harris on the subject of the "Stephenson" valve gear.

In the interests of historical accuracy, may I inform both your correspondents that this motion was, in fact, invented by William Howe, an ancestor of mine, in 1842, and not by Stephenson? The gear was applied by both George and Robert Stephenson (by whom Howe was employed) to a wide variety of stationary, marine and locomotive engines.

The correct designation and history is given in Burgh's "History of the Link Motion," and the original wooden model of Howe's reversing link motion can be seen in the Science Museum, South Kensington.

The gear was unfortunately never patented by him and it was not until later in life that he received some small recognition and acknowledgment from the engineers of Great Britain, who subscribed and presented him with an inscribed gold watch, an illuminated address and fifty guineas, all of which (except the fifty guineas!) are still in the family.

It is regrettable that the common error of attributing this invention to Stephenson should continue to be perpetuated in text-books, in technical college teaching and in references to valve motions everywhere, in spite of the evidence of its complete inaccuracy, a fact to which the attention of your readers was drawn in a copy of The Engineer many years ago.

W. L. Howe.

Liverpool, April 23rd.

INSTITUTION OF CIVIL ENGINEERS

Sir,—The Council of the Institution of Civil Engineers has recently issued papers to the members regarding a postal vote to be completed by June 17th, on two resolutions known as A and B. Resolution B was discussed at a general meeting held in October, and a summary of this discussion is included with the voting papers.

There has been no discussion, however, of resolution A and voters have no information about it other than a statement of objections to it issued by the Council.

Therefore I submitted to the Council some notes regarding considerations which, it seems to me, should be in the minds of members before they vote. The Council has, however, ruled that, once the issue of voting papers has been made, it would not be in order for any further statement to be issued, either by the Council or any individual members or groups of members.

Under these circumstances it would surely have been desirable to have given an opportunity for the expression of views on all aspects of the problems.

It would have been better to have confined such discussion to general meetings or to papers or publications issued by the Institution. Since, however, the ruling of the Council will not allow this, I should be obliged if you would publish this letter as the only means now open of placing certain considerations before members.

In the resolution passed at the special general meeting of January 3, 1946, the Council was requested to submit proposals for discussion at a special general meeting, which would be designed to secure to the corporate members adequate facilities for the nomination of candidates for election to the Council with suitable limitations, and to enable them to make informed use of their voting powers. This implied a submission of information which would enable the special general meeting to suggest modifications to be put to a postal vote along with the Council's proposals.

The Council's proposals, however, which were unaccompanied by any adequate report of members' proposals or of discussions of the many factors involved, provided that they should nominate thirty-one candidates, and that the local associations should nominate five. The provision for nomination by members was so restricted that in practice the result might be that the Council would still have the nomination of a majority of candidates whose election would follow automatically. In such a case the position would have remained much as it is now; except for the widening of contact of the Council with the members. No modification of these proposals was possible, and a formal expression of the opinion of the meeting was forbidden. Moreover, these proposals were accompanied by others referring to quite different subjects, which made it impracticable to effectively deliberate on the proposals for which the meeting had ostensibly been called.

It was because these objections were foreseen by some of the members who had prepared the resolution discussed and voted upon on January 3, 1946, that they hastily prepared resolution A and obtained signatures from members who were readily accessible in time to register their protest against resolution B before the special general meeting had been held to consider it. Under the circumstances this was the only way open to them to ensure that a vote should be taken on the Council's proposal. But that vote can now only be taken after the postal vote has decided the matter one way or the other, and will be futile.

It has been suggested that, since only thirty-six members have sent in proposals for election reforms, this indicates that the majority of members is satisfied with things as they are, and that to argue that postal votes had been unsatisfactory, was to cast a reflection on the intelligence of members. But there may be other explanations. Apathy, a feeling of frustration, and a lack of information may all play their parts. If members could, in fact, exercise their charter powers to elect the Council, and if the postal vote papers were normally accompanied by a report of the special general meeting held before instead of after the postal vote, there would perhaps be marked increase in the interest taken by the members in the affairs of the Institution. In the postal vote counted in February, 1945, only about 20 per cent of the members voted.

Experience has shown that discussion at a special general meeting is not in itself sufficient to solve satisfactorily the complicated problems now under consideration. It had been hoped that the Council would have appointed a special committee including corporate members not on

the Council to consider questions brought to its attention by the special general meeting of January, 1946, which could have dealt with the problems thoroughly in all their manifestations by quiet study and discussion.

If resolution B be carried, matters may remain in substance much as they are. But if resolution A be carried, there might be some hope that, by means of a special committee, as referred to above, and one or more special general meetings, principles would be arrived at satisfactory to the great majority of members. These principles could then be readily put into by-law form.

J. V. NIMMO.

Leeds, April 21st.

CORROSION OF TANKS

SIR,—It is well-known amongst sea-going engineers that plates of zinc are suspended in boilers to prevent corrosion of the steel boiler shell and tubes.

Recently I had occasion to open the cover of my galvanised iron domestic hot water tank and was perturbed to find the walls very heavily encrusted with rust on the walls and bottom.

The local plumber told me that he had had to renew several tanks in my road of about ten-year old houses, and said it was due to electrolysis, and though it is many years since I "swallowed the anchor," I was reminded of the above sea-going practice.

On consulting "Kempe's Engineer's Yearbook," I find that it is stated that the zinc must be in metallic contact with the shell of the boiler, but would appreciate the views of any reader who has made a study of the use of this method of rust prevention.

It seemed to me that if I laid the zinc on the floor of the tank a quicker rusting might take place at point of contact, and that if it were placed on a brick or piece of wood, that the water would conduct the action of wasting the zinc instead of the tank equally as well.

The loss to industry due to the rapid rusting of tanks must be quite considerable, and preventive measures should be more widely known.

T. W. BRYSON.

Knowle, Nr. Birmingham, April 24th.

INCENTIVES AND OUTPUT

SIR,—Re your article, "Incentives and Output," April 18th issue. I notice you do not compare raising the morale of a group with raising the morale of an individual, nor rewarding the efforts of a group with rewarding the efforts of an individual; you make a cross-comparison, *i.e.*, you compare raising the morale of a group with rewarding the efforts of an individual. From this you apparently think that raising the morale of a group is better than rewarding its efforts, but that rewarding the efforts of an individual is better than raising his morale. With this I disagree, and I write to say that I think the key to greater output lies in increasing the morale of the individual without reference to reward—though reward is also proper.

Increasing the morale means increasing that ability to get satisfaction out of doing things just to please others—or for others' good.

Dependence on a group leads to frustration.

ARTHUR F. WOODCOCK.

Leicester, April 23rd.

U.S. AIRCRAFT EXPORTS.—A report issued by the Office of International Trade, States that aircraft and aircraft accessory exports from the U.S.A. in 1946 were valued at nearly 155,000,000 dollars. The exports included 2343 civil aircraft, 59 military aircraft, and 2490 aero engines. A large proportion of these exports was Government surplus, but approximately 1400 of the aircraft were delivered from new production.

The Physical Society's Exhibition

No. IV—(*Continued from page 353, April 25th*)

WITH this article we conclude our description of a selection of exhibits at the research and trade sections of the Physical Society's Exhibition (London, April 9th to 12th).

ELECTRICAL RESEARCH ASSOCIATION

The exhibits in the research section included a range of instruments developed by the British Electrical and Allied Industries Research Association during the war for the location of bombs and mines. These detectors, which were being shown publicly for the first time, are of some topical interest, for they represent a wartime development possessing a number of useful peacetime applications. The brief account of the exhibits that follows includes an outline of the historical background to the work. During the war the problem of detecting ferrous type objects arose in a number of spheres of operation, mainly in connection with unexploded bombs and the clearance of beach minefields. The E.R.A. began investigations, in August, 1940, of the various methods for detecting unexploded bombs, including, in particular, the method involving the same principles as employed in their work on the degaussing of ships. Parallel investigations were started at the same time in eight other laboratories.

A preliminary fundamental study of the sensitivity required in an instrument measuring the distortion of the earth's magnetic field produced by the presence of the bomb showed that a differential magnetometer would have to register an anomaly in the earth's field of less than 1×10^{-7} gauss per centimetre in a reliable and reproducible manner. Moreover, this sensitivity had to be associated with robustness of design and portability. When the results of all the investigations were reviewed, in March, 1941, it was agreed that the mu-metal magnetometer developed by the E.R.A. was the best surface locator. Under the best conditions this instrument has successfully located 250-kg bombs at 15ft and 1000-kg bombs at 20ft—a remarkable achievement, although not meeting the original requirement, which, in fact, was never satisfied.

The same principle was used in the development of a beach mine locator, which was built in 1941 and utilised in the clearance of anti-invasion beach mines laid along our coasts. It located mines operationally at depths of 5ft. An improved version produced in 1944 has been put to most extensive use in the final clearance of mines prior to the civilian use of our beaches.

A further advance in the design of magnetic instruments was achieved in the direction of still greater sensitivity, involving long-period stability for the purpose of making continuous records, and resulting in the development of the recording magnetometer, of special application in the recording of magnetic storms. First exhibited at the Physical Society's Exhibition in 1946, this instrument forms the subject of a paper read before the Institution of Electrical Engineers on December 13, 1946, by Mr. A. Butterworth, who has been mainly responsible for the Association's work on magnetic locators.

Although developed essentially for military purposes, magnetic locators have a number of peacetime applications, in particular in connection with the salvaging of buried or submerged objects of iron or steel, since they can determine the position, depth and to some extent the shape of such objects to a considerable depth. A striking example of their use in this connection is afforded by the successful search recently carried out by E.R.A. engineers in an anchorage in the silted estuary of the River Seine, as briefly reported in *The Times* for April 2, 1947. The object of the searches was to locate the position of sunken anchor buoys and other equipment, as well as certain small vessels. Location of these objects by ordinary sweep methods employing a diver would probably have taken several months, whereas the high-sensitivity beach mine locator completed a successful sweep within a week, thus effecting considerable savings in time.

In principle, the locators are sensitive magnetometers for measuring the distortion of the earth's field produced by the presence of a ferro-magnetic material. The field-sensitive element is a length of mu-metal wire, the a.c. resistance of which varies with the field along the axis of the wire, this variation being associated with change of skin effect of the wire with magnetic saturation. Variation of the resistance is detected by a suitable bridge circuit operated at a frequency of 1000 c/s. Each locator has two sensitive elements, one vertically above the other, and the field gradient between the two elements is measured to give an indication of the presence of ferro-magnetic material, the earth's field being sufficiently uniform in the absence of any distorting influence.

The locator consists of two parts: a search unit or probe, containing the mu-metal elements in vertical alignment, and a cabinet housing the bridge and its auxiliary equipment. Three types of magnetic locator were exhibited: first, the original 6ft bomb locator that was issued to bomb disposal squads; secondly, the short-range bomb locator, a small portable model which was simpler than the original, although only slightly inferior in sensitivity and performance; thirdly, mine locator No. 1, Mark I. It was this mine locator that was used in the River Seine search referred to above.

Kindred techniques were later developed (by Mr. B. Rosenblum and other E.R.A. engineers) for the more general problem of detecting and locating non-ferrous bodies, such as the anti-tank and anti-personnel mines used by the enemy.

By 1943 various electro-magnetic methods were available for locating non-magnetic metallic bodies in the earth, by the detection of irregularities in an alternating magnetic field. These methods utilise an oscillator amplifier and search coils which are suitably disposed to reduce mutual inductance, except when a metallic object is in the vicinity. A drawback of such methods, for the present purpose, is that they are also sensitive to the soil and particularly to extraneous magnetic bodies, such as rock, ferro-concrete, and paving stones. Discrimination can be attained by utilising the phase difference between signals due to highly conductive bodies (whether ferro-magnetic or not) and those due to poorly conducting ferro-magnetic bodies, such as magnetic rocks.

Working on these lines, the E.R.A. developed a locator consisting of an oscillator, an amplifier, a mixer and two coils mounted in the search head, coupled to the oscillator output and amplifier input respectively. Since the oscillator valve is separate from the amplifier (the equipment differs in this respect from discriminating locators later developed), constant signal frequency and phase relationship are ensured, resulting in high stability of the equipment. The effect of the soil or of large bodies can be minimised by a geometrically balanced system, and the E.R.A. has developed a concentric coil system with vertical balancing coils to compensate for tilt; a locator of this type can be handled much more freely than uncompensated types, which must be carried more or less level with the ground and which require discriminating devices to minimise the effect of proximity to the ground.

To indicate the sensitivity of the E.R.A. locator it can detect a Teller (anti-tank) mine in non-magnetic surroundings at 42in, brass sheet (13in by 13in by $\frac{1}{16}$in) in non-magnetic surroundings at 44in, or at 30in to 35in when bedded in ferro-magnetic clay. The range of this instrument and of the other mine detectors,

operating on the mutual inductance principle, is ultimately limited by the magnetic properties of the ground. Within the operating range, however, the equipment is useful when it is desired to discriminate between metallic and low-conductance ferro-magnetic bodies or between various sizes of metallic objects.

Another class of instrument, a locator with a remote field source, is the outcome of the requirement for eliminating the effect of the ambient ground, of interference between operators and of explosive devices which could be ignited by the field of the preceding locators. The basis is that of ordinary electro-magnetic prospecting, involving the establishment of an alternating field over the area of the earth to be searched, by means of a cable laid in a loop of large area on the ground in the vicinity.

× 10,000

FIG. 18—"SHADOW CAST" OF MAGNESIUM-OXIDE SMOKE—METROVICK

Whereas the ordinary methods involve a plotting of the field, the present method yields the location directly. The search head of the equipment consists of a coil system balanced against the field due to the cable loop while remaining sensitive to local field distortions caused by the presence of metallic or magnetic bodies. The search equipment also includes a control unit, an amplifier and a compensator. The object of the compensator is to retain a uniform sensitivity of location while moving away from the cable loop, *i.e.*, while the magnetic field in the vicinity of the search unit is reduced. This is achieved by a novel circuit, which is capable of measuring a ratio or a product of two quantities

FIG. 19—LAMINATION DETECTOR—METROVICK

directly and thus can be applied generally in other kinds of instruments. This locator is quite insensitive to uniformly distributed magnetic bodies, *e.g.*, soil itself, but detects any discrete metallic objects, magnetic or conducting. As compared with the previous locator, this one has a considerably greater range. Discrimination between magnetic and non-magnetic material can also be applied as an adjunct.

In wartime the locator with remote field source was used for mine detection over large areas, and was successful in tracing Teller mines to a depth of 5ft. An important peacetime application is in geophysical prospecting which calls for greater detail in shallow formations than does ordinary prospecting. Other possible applications include the location of underground cables and pipes.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LTD.

"Shadow casting" is a recent development in the technique of electron microscopy. Shadow casts are formed by irradiating a supported specimen obliquely, *in vacuo*, with a stream of molecules of metal (usually gold). Under such conditions the specimen, when viewed by transmission in an electron microscope, shows shadows and gradations of density which reflect the detailed shape of the surface of the original specimen.† The apparatus used in shadow casting comprises a support for the specimen holder and a source of the molecular beam in the form of a bead of gold fused to the tip of a tungsten hairpin filament. The direction from which the beam falls on the specimen can be controlled by a preliminary adjustment of the apparatus. When in use the equipment is enclosed in an evacuated vessel, under a pressure of less than 10^{-4} mm, and the filament is heated by current from an external source.

Exhibits shown by M-V. Electrical Company, Ltd., in the research and educational section, included a number of electron micrographs of specimens that were "shadow cast" in the apparatus described above; a typical example, Fig. 18, is reproduced from a micrograph "shadow cast" of magnesium oxide (MgO) smoke, taken with the specimen inclined at 45 deg. to the beam of gold molecules.

Amongst a number of interesting exhibits in the trade section of the exhibition, the same firm demonstrated their "Metroflux" lamination detector, which is the development of an experimental equipment originally made for the detection of laminations (rolled-out pipes) in steel sheet. The detector (Fig. 19) can also be used to test bearings for the satisfactory adhesion of white metal linings and to test small brazed joints, bimetal strips, &c. Various forms of testing tongs can be supplied to suit individual applications; the tongs illustrated in Fig. 19 are suitable for a considerable variety of small bearings. In addition, jig type tongs, suitable for the continuous examination of strip material, can be supplied.

The method of testing is to apply one current contact and one potential contact to each surface of the material. The current contacts pass current through the thickness of the material; the other contacts are used in measuring the potential difference between the two sides. Any discontinuity in the electrical conditions, such as is associated with a defect lying across the path of the current, modifies the current flow and the potential difference at the contacts. This change is indicated on a reflecting galvanometer.

† Williams and Wyckoff, *J. App. Phys.*, 15, 712 (1944).

THE CAMBRIDGE INSTRUMENT COMPANY, LTD.

An accurate knowledge of the camber and profile of rolls used in sheet rolling mills is essential if high-quality work is desired. A roll camber recorder designed and exhibited by the Cambridge Instrument Company, Ltd., 13, Grosvenor Place, London, S.W.1, allows an accurate record of the profile of the roll to be made during and after grinding. From this record the camber can be determined immediately. The Cambridge roll camber recorder consists of a cradle carrying a recording unit, which is applied to the roll and traversed from end to end. It produces on a celluloid tape a small but accurate record of the profile of the roll. Being non-photographic, this record is immediately available for inspection; a convenient form of portable projector is provided for the examination of the record. This record is a scale reproduction of the profile of the roll, and with the help of a graticule in the projector it is possible to measure the camber to an accuracy of 0·0002in. At the same time the apparatus will indicate the extent of any tapering or any surface irregularities on the roll. In the vertical direction the projection viewer presents a highly magnified record so that one square on the graticule represents 0·002in. In the horizontal direction one square represents 3in of movement along the roll. Thus it is possible to see, in the viewer, the whole profile of a roll 5ft long with a camber less than 0·035in, while the position of any surface defect can be determined to within 0·3in.

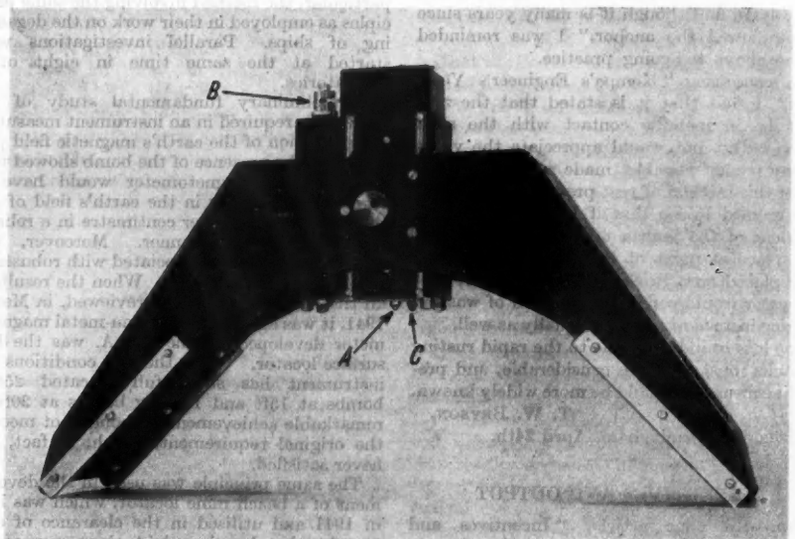


FIG. 20—ROLL CAMBER RECORDER—CAMBRIDGE

Two sizes of cradle are available and one or the other will accommodate rolls of any diameter between 15in and 38in, and the recording unit, which is a self-contained easily detachable unit, is interchangeable for either cradle. In use the cradle is placed astride the end of the roll on which it is seated geometrically by four accurately ground steel straight-edges. The measuring unit is then lowered until a bearing toe A, shown in Fig. 20, meets the surface of the roller and the mechanism is unclamped when the recording stylus takes up a zero position on the celluloid tape B, which is driven by the friction wheel C bearing on the roller.

When the instrument is traversed by hand along the roll the recording tape moves in

accordance with the speed and length of the movement, while the bearing toe which actuates the recording stylus follows the camber of the surface. The records can be obtained in a few moments and several records can, if desired, be taken at various stages during the process of grinding the rolls. There is no necessity for removing the rolls from the machine or mill, provided that there is no obstruction to the firm seating of the cradle or to its subsequent traverse.

Royal Aircraft Establishment

Apparatus that was shown in the research section of the R.A.E., Farnborough, was indicative of that establishment's interest in the measurement of electrical and mechanical quantities directly or indirectly associated with aviation, including such matters as the suppression of electrical interference and the measurement of engine torque and power.

Of general interest was an extensometer calibrator, which was designed in the first place for internal use within the R.A.E. to provide a method for the absolute calibration of extensometers used in the mechanical testing of materials. The extensometer consists essentially of an artificial test piece in which known elongations can be produced: a rod is divided into two portions, one fixed and the other movable in a direction parallel to the axis of the rod, the movement being produced by a micrometer head through a system of spring-hinged levers, so that the movement can be controlled to better than 10^{-6}in. The extensometer that is being calibrated is attached to the rod in such a way as to indicate the relative movements of the two parts of the rod. The displacement of the moving portion relatively to the fixed portion is then determined by observation of the movement of interference fringes that are set up between two glass plates, one of which is fixed while the other is attached to the moving portion. A microscope allows fringe positions to be estimated to one-tenth of the fringe spacing and thus the extension applied to the extensometer can be determined to within approximately 10^{-6}in.

Work of the Iron and Steel Board

The Iron and Steel Board was appointed on September 5th last year. Early this week, Sir Archibald Forbes, its Chairman, gave some account of its activities during the last six months.

The Board, he said, effectively took over its duties on October 2, 1946. Briefly, its work fell under three heads:—

(1) Reviewing schemes for modernisation and development.

(2) Exercising general supervision over the industries concerned, including:—

(*a*) The administration of such direct control as may be necessary of production, distribution and import of iron and steel.

(*b*) The provision of the raw material requirements.

(3) Advising on general price policy and the fixing of prices for controlled products.

The following is an abstract of his further remarks:—

It is important to realise that the process of modernisation and development in these industries must have regard to the maintenance of current production. Moreover, any general plan formulated at a particular point of time is part of a continuing process and would normally be followed by further proposals when those contained in it were nearing completion. It has also to be borne in mind that the resources of this country in the requisites of constructing capital works—manpower, materials, equipment for plant manufacture and foreign exchange—are limited, and that there are many competing demands upon them.

In considering proposals in this field, the Board examines them from many aspects, including:—

Their relationship to any general plan; their relationship to current and probable future demand and existing and projected capacity; the availability and source of raw materials, including fuel; their relationship to the most modern practice here and abroad on the criteria of maximum efficiency and fullest economy in cost; the economics of the location regarding the supply of raw materials and delivery to consumers; the degree of rationalisation among the different plants and the integration of manufacture within individual plants; and the availability of labour, housing and amenities.

Generally, the Board is primarily concerned with the economic aspects of new projects from the standpoint of the cost and efficiency of steel production though it recognises that there may be cases where these have to be subordinated in some degree to wider considerations such as the social disturbance factor.

When a project has been approved by the Board it is then subject to the normal Government licensing machinery. Either before or after the Board reaches a conclusion in the matter, the various interested authorities have to consider the project from their standpoint, for example, the Board of Trade and Ministry of Town and Country Planning on the general location of industry, the Ministries of Works and of Labour on the availability of constructional and operational labour, the Ministry of Health on the availability of housing and the Ministry of Fuel and Power on the availability of coal and electricity and gas supplies, and other Departments interested to the extent of the effect upon other important constructional programmes. The final decision is made by the Government upon the combined advice of the various Departments.

Modernisation Plan

In putting forward its plan for modernisation and development, the British Iron and Steel Federation based it upon a capacity of between 15,000,000 to 16,000,000 ingot tons a year and pointed out that it should be regarded in the light of a first stage. Without commitment as regards the nature or extent of individual projects, the Board accepts the aim of this plan in relation to overall capacity as it considers it represents the practicable maximum over the next few years. The Board also accepts the broad distribution of capacity as set out in this plan. That plan envisaged projects estimated to cost about £168,000,000, spread over a period of about 7½ years.

Projects, the cost of which amounted to about 10 per cent of the total, had been licensed and commenced prior to the setting up of the Board. Projects likely to cost over £100,000,000 have been generally approved by the Board and about two-thirds of these projects have been approved in complete detail. Further projects involving an expenditure of approximately £20,000,000 have been submitted to the Board in detail or outline and are under consideration now.

It is difficult to make an accurate assessment of the proportion of schemes approved in relation to the total plan because of the constantly rising level of capital cost which affects estimates made at differing dates and certain variation within the plan itself. But it would be safe to say that over half of the projects envisaged in the Federation plan have been approved and work is under way in the majority of these. Planning in connection with the remainder of the projects is proceeding satisfactorily and most of them will come before the Board in the near future.

Foundry Iron and Iron Castings

The Board has kept in close touch through the J.I.C. with the Council of Iron Producers and the Council of Iron Founders Associations Following discussions with the Board, the Council of Iron Producers has been engaged in preparing an overall plan for the modernisation and development of the foundry iron industry, which the Board hopes to receive very shortly. In the interval, the Board has approved two minor schemes for this industry and is on the point of completing its examination of one major scheme. The iron foundry industry has a very complex nature, embracing nearly 2000 firms, some of whom are not members of the organisations affiliated to the Council of Iron Founders' Associations. After consultation with representatives of the industry, it was decided that the first step should be to obtain a reliable picture of the industry as a whole, particularly as regards the amount of modernisation and development work which had been carried out in recent years or was now in hand or in prospect. It was done by a questionnaire, whose results are under consideration now.

The Board is ensuring that development of the iron ore industry proceeds in keeping with the development of the iron and steel industries.

Supervision of Production, Distribution and Imports

In this field the Board has been mainly concerned in assisting the industries in their endeavour to achieve maximum production from existing resources, frequently under difficult conditions. Last year, production in this country reached about 12¾ million ingot tons and would have been higher had the full requirements of fuel and transport been available. The demands, so far as it could be assessed, and this is given with considerable qualification, was for nearly 15,000,000 ingot tons. It had been hoped to make good this difference or a large proportion of it, by import, mainly from the U.S.A., but it proved impossible to obtain deliveries from all overseas sources of more than about 400,000 tons of steel of all descriptions.

This year I am confident that but for the unfortunate shortage of coal, steel production in this country would have exceeded 13,000,000 ingot tons and in fact achieved an all-time record. Production has, however, been severely affected by lack of fuel and power. Actual production to the end of March was 2,800,000 tons, equivalent to a rate of under 11,500,000 tons a year, while at its worst, production dropped below an annual rate of 10,000,000 tons. Although matters are now improving, coal supplies are still below full requirement and until more is known about the level of supply for the remainder of the year, it is impossible to attempt to forecast the level of steel production during 1947.

Every effort is being made to obtain further supplies of steel by import, but the high level of overseas demand in relation to current supplies operates to curtail the quantity available for purchase by this country. During the first three months of this year imports were under 120,000 tons from all sources, and there does not seem much prospect of this rate being increased, at any rate, until the latter part of the year.

Conversion to Oil Burning

Constant efforts have been made to increase production in this country, notably by the conversion of steel furnaces and ancillary heating services from coal to oil burning, the fullest practicable use of electric furnaces for the manufacture of carbon steel and the introduction of the continuous working of steel furnaces.

Conversion to oil burning has already reached a stage when oil consumption is at a rate of about 250,000 tons a year (representing a saving in coal of 450,000 tons a year), and it is hoped by the end of the year that this will have risen to not very far short of a rate of 1,000,000 tons a year, (representing a saving in coal of 1,800,000 tons a year). The pressure on industry in general to convert to oil burning has, however, created difficulties in the supply of the necessary equipment.

The bringing in of electric furnaces to manufacture carbon steel (which is not gener-

ally economic) has been impeded by the shortage of electric power.

The introduction of the continuous working of steel melting furnaces came into force early this month, and it is therefore too soon to say what its effect will be. In a full normal year it might have been expected to produce an extra 750,000 ingot tons, but here, again, the full benefits cannot be obtained in the absence of adequate supplies of fuel.

It has been suggested that the use of a higher proportion of scrap would give greater output and economise in the use of coal. Within limits this is so, but the present overall average consumption of scrap is just over 60 per cent, and there is no possibility of increasing this with the current supply of scrap. The scrap situation is in fact one which is a source of concern both to the industry and the Board and is under examination by all parties now.

I have already remarked that the allocation of steel supplies and iron castings is not a matter for the Board. It is controlled centrally by the Raw Materials Sub-Committee of the Cabinet Offices, which meets quarterly and determines the allocation of supplies to the various Government Departments sponsoring the various branches of industry for the ensuing period of three months. These allocations are made in accordance with the Board's estimate of the availability of supplies and in accordance with a list of priorities which you will be aware has recently been issued by the Cabinet. These priorities apply equally to: electricity generating plant required by electricity undertakings; machinery and equipment for deep-mined and open-cast coal production; plant and equipment required by gas undertakings; equipment for the coal-oil conversion programme; freight locomotives, railway wagons for the transport of coal, and steel rails for essential maintenance of the permanent way; and atomic energy.

The Board exercises general supervision of imports of iron ore, manganese ore and ferro-alloys, and is responsible through companies set up for the purpose, for the imports of steel (both new and scrap) and the disposal of Government surpluses in the form of steel and steel scrap, mostly arising from adjustments following the end of the war.

Price Control

Lastly there is the field of advising on prices. The Board's independent adviser has under continuous examination the costs of production of the various controlled products and in the light of this information and other relevant factors the need for the adjustment of prices either upwards or downwards is kept under constant review.

Marconi Company's Jubilee

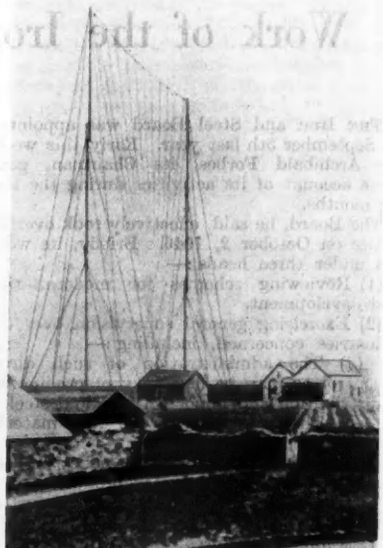
WIRELESS telegraphy celebrates its fiftieth anniversary this year by an exhibition in London at Queens House, Kingsway, showing the development of Marconi's invention from the first crude apparatus with a range of a few miles to the most modern apparatus in world-wide use to-day.

The exhibition, which closes to-day, Friday, May 2nd, at 6 p.m., contains a collection of apparatus, model reproductions and photographs arranged chronologically to show the contribution made by Marconi to the science of wireless communication and broadcasting. Bridging fifty years of development, our first illustration herewith is reproduced from a photograph of Marconi taken in London in 1896. This engraving shows the young inventor with his original transmitting and receiving apparatus. On the left is a Righi oscillator (now known as a Hertz dipole aerial). Working at 1 m to 1·5 m, this device formed the first short-wave transmitter. The black box on the right of the photograph contained a coherer, tapper and relay connected between the two horizontal copper strips, which acted as the receiving aerial. On the top of the box was an ordinary Morse sounder which could be replaced by a bell or tape recorder, as required. This simple and compact apparatus embodied the genesis of commercial wireless communication.

It was in 1897 that Marconi gave a decisive demonstration of his system of "telegraphy without wires" to Sir William Preece, C.B., F.R.S., the then engineer-in-chief of the G.P.O. This demonstration, which took place between Lavernock and Brean Down across the Bristol Channel, convinced Sir William Preece of the practicability of the Marconi system, and laid the foundation of future development. Later that year the Wireless Telegraph and Signal Company, Ltd., was formed to acquire the Marconi patents and to develop them commercially. Thus began a great new British industry—an industry which within a few years was to provide employment directly or indirectly to thousands of workers and which was destined to bring a new experience into the homes and lives of ordinary people. Three years later the name of the company was changed to Marconi's Wireless Telegraph Company, Ltd. The same year (1900) saw the formation of the Marconi International Marine Communication Company, Ltd., which was formed to develop the use of wireless at sea.

The first permanent wireless station ever to be built was erected by the Marconi Company at the Needles, Isle of Wight, in 1897, and communication was established with Bournemouth, 14½ miles away. It was from this station, a year later, that the first paid wireless message was sent. In 1897 also the first use of wireless by Royalty was made when the Prince of Wales maintained wireless contact with his mother Queen Victoria from the Royal Yacht to Lady-

MARCONI AND HIS ORIGINAL SHORT WAVE APPARATUS IN 1896



MARCONI STATION AT POLDHU, CORNWALL

wood Cottage, Osborne, for sixteen days. The first application of wireless to journalism occurred in 1898 when Marconi technicians reported the events of the 1898 Kingstown Regatta from the steamer "Flying Huntress" by arrangement with *The Dublin Express*. The first use of wireless as a means of summoning help at sea occurred in 1899, when a collision was reported by a Marconi installation on the East Goodwin Lightship to the South Foreland Lighthouse. This was one of the earliest "ship-to-shore" radio links, and from the time it was installed it was responsible for the saving of many lives as well as much valuable property. By 1899 the range of wireless had increased and during that year two British warships spoke to each other over 85 miles of water.

Greater achievements were to come. For some time Marconi had held the belief, against the general scientific opinion of the time, that world-wide communication was possible. Accordingly, the Marconi Company set about the construction of a station far greater in power than anything yet conceived. The site chosen for this historic station was at Poldhu in Cornwall. By the autumn of 1901 the Poldhu station (illustrated herewith) was completed, and Marconi, with two assistants, Kemp and Paget, set sail for Newfoundland. There, on Signal Hill, they set up their receiving apparatus, and made preparations for the reception of the first wireless signal across the Atlantic. Finally, on a stormy night in December, 1901, their faith and patience were rewarded when they heard the three faint clicks in their earphones, the

pre-arranged Morse letter S—wireless had spanned the Atlantic! Within a year, complete messages were being sent, and shortly afterwards the first transatlantic wireless service became an accomplished fact.

The successful introduction of a transatlantic wireless service led to the germination of an idea for an Imperial wireless chain, and in 1908 the Marconi Company sent one of its engineers to South Africa, partly in the normal way of business and partly to sound the degree of interest felt there in an Imperial wireless network. Four years later, in 1912, the Government, convinced of the practicability of the scheme, gave a contract to the Marconi Company which commenced construction work on the first stations. This work was interrupted by the first world war, after which construction was recommenced on an Imperial chain of wireless stations, which were to use long waves, on the principle that "the longer the wavelength, the greater the range." Then came the revolutionary invention of the Marconi-Franklin short-wave beam system

For some time Marconi engineers, reverting to one of Marconi's earliest ideas, had been experimenting with various types of directional or "beamed" transmission, using short waves, and had discovered that far greater ranges could be obtained with the use of much less power. Patient experiments substantiated this theory and a revolutionary advance was made when the Marconi Company announced that it was prepared to produce an alternative Imperial wireless telegraph chain which would involve the use of one-fiftieth the power, would cost one-twentieth as much as the system then under construction, and would permit transmissions at three times the speed. These new claims were too sweeping to be disregarded. Demonstrations were called for and were successful. The Post Office cancelled the original plan and made a new contract, whereby Marconi's were to undertake the construction of a system of short-wave Imperial wireless telegraph stations, embodying the use of the Marconi-Franklin "beam" principle. The success of the services provided by these stations is a matter of history.

There was yet another use to which Marconi's invention was to be put, bringing wireless out of the realms of pure communication into the entertainment field. The invention of the thermionic valve by Sir Ambrose Fleming led directly to the development of this new application of wireless now known as broadcasting. In 1919 a Marconi engineer broadcast speech from Ireland to Canada, and within the next few months intensive experiments in this new development took place. As a result, in 1920, a broadcasting transmitter was erected at the Marconi Company's works at Chelmsford, Essex, and this transmitter broadcast entertainment programmes which were heard in many different countries. There followed regular broadcasts from a low-power station at Writtle (2MT) and later from the first London station (the famous 2LO) at Marconi House in the Strand, before the latter station was taken over in 1922 by the British Broadcasting Company (now the British Broadcasting Corporation). Later, Marconi engineers played a prominent part in the design of the first television equipment ever to be put into regular service at the Alexandra Palace for the B.B.C. in 1936.

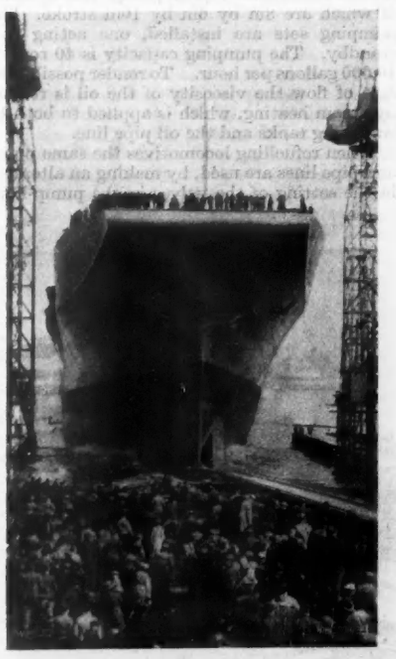
Modern applications of wireless technique, directly descended from the early pioneer achievements, form a separate section of the jubilee exhibition, which contains a short-wave high-speed telegraph and telephone transmitter, similar to that installed in the pilot train for the Royal tour of South Africa. Modern broadcasting is represented by a 20-kW medium-wave transmitter. Two exhibits in particular illustrate modern trends towards mobility—a miniaturised v.h.f. amplitude modulated transmitter and receiver for use in police cars, &c., and a mobile telegraph and radio telephone equipment designed for operation in remote and difficult country. Communication equipment for ship and aircraft is well represented and several exhibits are devoted to airborne and marine navigational aids based on direction-finding principles as well as radar.

Launch of Light Fleet Carrier H.M.S. "Centaur"

On Tuesday, April 22nd, at 12.45 p.m., the light fleet carrier H.M.S. "Centaur" was launched from Harland Wolff's Belfast yard. The naming ceremony was performed by Her Royal Highness the Duchess of Kent.

The light fleet carrier type of warship was, it will be recalled, originated during the war, when there was a demand for more and more aircraft carriers capable of working with the fleet on offensive operations. Among the design requirements were a good turn of speed, great steaming endurance, and facilities for operating and maintaining the aircraft for prolonged periods without assistance. The construction of these ships had to be simplified in order to permit rapid building, and some qualities of the fleet carrier had to be sacrificed, but the light fleet carrier is nevertheless a very powerful warship.

Harland and Wolff, Ltd., built at Belfast two light fleet carriers of the "Colossus" class,



LAUNCH OF H.M.S. "CENTAUR"

H.M.S. "Glory" and H.M.C.S. "Warrior," the first of which ships saw service in the Far East during the months before the Japanese surrender. The arrangements for operating the aircraft on these ships closely resemble those in the fleet carrier H.M.S. "Eagle," which was launched by Her Royal Highness the Princess Elizabeth from a neighbouring slipway in 1946. The design of the light fleet carrier was the subject of a long series of model experiments to determine the best shape of hull for speed, endurance and seaworthiness, while the strength and rigidity of the hull structure were also subjects of special investigation. In the construction of the hull of the ship electric welding was extensively used, and X-ray testing of welding, now a standard procedure in shipyards, was employed, a team of young scientists, with their radiographic equipment, being a frequent and familiar sight among the workmen during the construction of the "Centaur."

The geared turbine propelling machinery was made by Harland and Wolff, Ltd., at the firm's Queen's Island Works, and it embodies the latest practice. The increased electric power now used in naval vessels calls for considerable generator capacity, which is furnished by steam turbine driven and oil engine driven generating plant, with elaborate safeguards for the maintenance of supplies to all services in the event of damage. More than 250 miles of electric cables were installed in the ship. During the course of construction a number of changes were introduced into the design so as to bring it completely up to date. The living quarters, as regards mess decks and dining halls, were arranged on the same system as that adopted for the battleship H.M.S. "Vanguard." Many of the living compartments will be provided with air-conditioned ventilation. Electrical machinery is used for catering and cooking operations and more refrigerated space than usual is reserved in "cold" and "cool" rooms, which arrangement, it is stated, will ensure a more varied diet than has hitherto been possible in warships. The radar and wireless equipment is numerous and varied, and it was a matter of ingenuity to find positions for all the aerials without loss of efficiency and without infringing on the areas kept clear for aircraft. Internal telephone communications and loudspeakers are employed to relay messages to any working position in the ship. The "Centaur" is the eighth aircraft carrier to be launched at Belfast, and she will join H.M.S. 'Eagle" at the fitting-out wharves.

Instrument for Testing Vacuum Brake Systems

A new portable instrument for detecting and measuring leakage in the automatic vacuum brake system of railway vehicles has been developed in the research laboratories of the London, Midland and Scottish Railway Company. This instrument, a photograph of which is reproduced below, provides a simple and convenient means of leakage testing and permits the quick and easy checking of vehicles periodically or at any desired time at out stations. As can be seen, it is compact and is sufficiently light, weighing only 16 lb, for manipulation by one man. It shows at a glance whether the rate of leakage into an evacuated brake system is greater or less than a tolerable value. The instrument is based upon the principle of comparing a slow standard leak against the actual leakage into the brake system of the vehicle under test.

The standard leak in the instrument is obtained from a length of capillary tubing, through which air from the atmosphere slowly

INSTRUMENT COUPLED TO TRAIN VACUUM SYSTEM

leaks into a small, evacuated cylinder or reservoir. The bore of the capillary is such that a convenient straight length of tube gives the desired standard leakage, arbitrarily fixed at 2in Hg. (from about 21in Hg. to 19in Hg.) in one minute. The outer end of the capillary is soldered into a screwed brass plug, by which it is sealed into one end of the cylindrical reservoir with the length of tube inside. A filter inside the plug, which is hollow, excludes dust from the air leaking in through the capillary. A feature of the capillary tube is that its leakage rate can be readily calibrated by adjusting its length.

The actual and standard rates of leakage are indicated by means of a specially designed duplex vacuum gauge comprising two separate

elements having concentric spindles carrying pointers moving over a single dial. This gauge is mounted, at a convenient angle, on a compact assembly consisting of two vacuum hose couplings with an interposed isolating cock. The spindle of the isolating cock carries a separate cock, whereby the reservoir fitted with the standard leak can be evacuated and subsequently isolated. One element of the duplex gauge is connected to the "leak reservoir" and has a red pointer; the other element, actuating a black pointer, is connected between the main isolating cock and one of the hose couplings, which is always connected to the vehicle under test.

To make a test, the train pipe at one end of the vehicle is closed by its stopper, and the instrument is coupled between the other end and a source of vacuum, which may be an engine, with or without vehicles attached, or a separate mechanical evacuator. The operating handle is moved to a position in which the same vacuum is created in the standard leak reservoir of the instrument as in the brake system of the vehicle under test. Both pointers of the duplex gauge move to indicate the same, maximum, vacuum. When this is attained the operating handle is moved to the "test" position, separately isolating the leak reservoir and the brake system under test.

A refinement of the phase displacement of the two isolating cocks, or an appropriate method of using the instrument, ensures that immediately after the instrument is isolated from the evacuating source, the leak reservoir is left momentarily in communication with the system under test. By this precaution the reservoir and the system under test are both brought to exactly the same vacuum before finally being separately isolated.

The red and black gauge pointers are thus originally coincident. As the vacuum falls they move at different rates, showing at a glance whether the brake system is leaking at more or less than the permissible rate. The actual rate of either leakage can, of course, be readily timed with a stop-watch, and an occasional check of this sort is desirable to confirm that the standard leak rate is being maintained.

We are informed that this instrument was devised by Mr. J. O. Cowburn, formerly of the engineering section of the London, Midland and Scottish Railway research department, who was recently awarded the company's "Herbert Jackson" Prize for this particular piece of work.

I.E.E. ANNUAL REPORT.—The Institution of Electrical Engineers says that copies of the annual report of the council for Session 1946–47 and of the accounts for the year ended December 31, 1946, to be presented at the annual general meeting on May 15, 1947, can now be obtained by members on application to the Secretary.

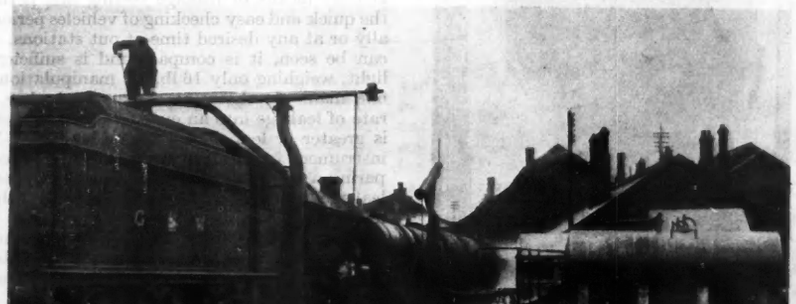
Oil Storage Depots on the G.W.R.

THE Great Western Railway Company has now put into service the first of fourteen new oil storage plants which are being installed at various running sheds for use in connection with fuelling the locomotives now being converted to burn oil fuel. Prior to the last big locomotive conversion scheme the company had already installed oil storage plants at Severn Tunnel Junction and at Llanelly. A photograph of the latest of these storage and fuelling plants, at the Swindon running shed, is reproduced in the accompanying illustration. It is generally similar to the two depots in South Wales.

It has three storage tanks, each 30ft long by 9ft diameter and of 12,000 gallons capacity. The tanks are replenished from travelling rail tanks of 3000 gallons capacity. Oil from the travelling tanks, three of which can be dealt with at a time, is transferred through flexible hoses to the storage tanks by a steam-driven horizontal duplex pump, the cylinders of which are 8in by 6in by 10in stroke. Two pumping sets are installed, one acting as a standby. The pumping capacity is 40 tons, or 10,000 gallons per hour. To render possible this rate of flow the viscosity of the oil is reduced by steam heating, which is applied to both the travelling tanks and the oil pipe line.

When refuelling locomotives the same pumps and pipe lines are used, by making an alteration in the setting of the valves in the pump-house to withdraw oil from the storage tanks. The storage tanks are also steam heated and from them oil is pumped in the reverse direction through the pipe line to two overhead jib arm standpipes. These standpipes, which are of the company's own design, are arranged for the jib to have approximately 120 deg. of movement in the horizontal plane, with a rise and fall of approximately 30 deg. A counterbalance weight is provided to tilt the jib so that the oil drains away from the mouth of the filling pipe when the standpipe is not in use. The flexibility on the oil supply line has been obtained by the introduction of a 14ft length of flexible oil hose between the standpipe and the nozzle at the end of the jib. The pintle and trunnion bearings of the jib arm are of steel with bronze bushes. The fuelling rate can be maintained at the maximum capacity of the pump—10,000 gallons per hour.

A stationary boiler of the standard locomotive type has been provided for steam heating the oil pipe lines and the storage tanks, the temperature of which is maintained at the required level by thermostatic control apparatus. This boiler also supplies the existing steam main in the running shed, originally provided for hot water boiler washing, and from which the steam necessary for lighting up oil-fired engines from cold may also be obtained.



OIL STORAGE DEPOT AT SWINDON

Magnetic Alloy for Lightweight Motors

A NEW 35 per cent cobalt-64 per cent iron-1 per cent chromium alloy, claimed to have a higher magnetic saturation point than any other alloy practical for use in motors and generators and tough enough to withstand intense vibration, has been developed by Dr. Trygve D. Yensen, of the research laboratories of the Westinghouse Electric Corporation, Pittsburgh, Pa., in collaboration with Mr. J. K. Stanley. The new alloy, "Hiperco," will make possible compact electric motors and generators estimated to be 10 per cent smaller and lighter than those of equal power now built for aircraft. The combination of 35 per cent cobalt with iron is said to give the highest magnetic saturation point of any known metallic material, and the 1 per cent chromium is added to make the alloy workable.

The new alloy is the result of twenty years' research, with the final difficulty of brittleness being overcome only recently. Earlier samples of Hiperco were too brittle to be of great use. A method was devised, however, of rolling, which permits production of a tissue-thin strip of metal tough enough to withstand vibration and yet ductile enough to be bent double without breaking. Formerly the metal was hot-rolled and allowed to cool slowly, but unlike ordinary iron and steel, cobalt-iron becomes brittle when it cools in this manner. It has been found that brittleness can be avoided either by quenching the alloy in cool water or by continuous rolling, while the hot metal cools. With the quenching method in use, Hiperco ingots are rolled into slabs 2in to 3in thick, reheated to a high temperature, and rolled again to a thickness of $^1/_{16}$in. As the strip emerges from the last set of rolls, it plunges into a trough of cooling water.

The sudden cooling makes the metal strong and workable, so that it can be coiled like wire. The cool metal then goes through a cold-rolling process, which can further reduce its thickness to as little as 1/2000in. For most motor and generator applications, however, a thickness of approximately 1/200in is sufficient.

Cobalt is a costly material, but the new alloy is considered to be of value for small and light motors and generators. New supplies of cobalt are being sought in the United States, Canada and China. If sufficient is found, Hiperco might replace other metals in many types of motors and generators. To-day, however, its cost limits its use to such applications as aircraft, where savings in weight and size are important.

BOOKS RECEIVED

Whitaker's Almanack. 1947 edition. London: J. Whitaker and Sons, Ltd., 13, Bedford Square, W.C.1. Price 12s. 6d.

Ports of the World. London: The Shipping World, Ltd., Effingham House, Arundel Street, Strand, W.C.2. Price 30s.

Structural Analysis. By W. Fisher Cassie. London: Longmans, Green and Co., Ltd., 43, Albert Drive, S.W.19. Price 16s.

Building and Structural Tables. By F. H. Blake. London: Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 21s.

Precision Workshop Methods. Second edition. By H. J. Davies. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 20s.

Screw Tug Design. By A. Caldwell. London: Hutchinson and Co. (Publishers), Ltd., 47, Princes Gate, Exhibition Road, S.W.7. Price 18s.

Principles of Electrical Engineering. By T. F. Wall. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 40s.

Geometrical Properties of Ship Girders and Sections. Third Edition. London: Lloyd's Register of Shipping, 71, Fenchurch Street, E.C.3. Price 20s.

British Catalogue of Plastics. Edited by E. Molloy. London: The National Trade Press, Ltd., Drury House, Russell Street, W.C.2. Price 50s.

Locomotive Running Shed Practice. By Harry Webster. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 18s.

Marginal Costing. By F. C. Lawrence and E. N. Humphreys. London: MacDonald and Evans, 8, John Street, Bedford Row, W.C.1. Price 12s. 6d

Canadian Engineering Notes

Aluminium Company Expansion

A 500,000-dollar expansion programme for its Shawinigan Falls works is announced by the Aluminum Company of Canada, Ltd. It will increase capacity by approximately 30 per cent. This expansion comprises the purchase of new stranding and wire-drawing machines, together with alteration to existing building at Plant No. 1, and is made necessary by the present and expected demand for aluminium cable and other aluminium wire products.

New Petrol Facilities

Shell Oil Company of Canada, Ltd., is embarking upon an extensive construction programme at Shellburn Refinery, which is situated some four miles beyond the city limits of Vancouver, on Burrard Inlet. The cost of the new additions will be approximately 1,700,000 dollars. The new facilities include a two-coil thermal cracking unit, a U.O.P. catalytic polymerisation plant, a continuous acid treater and columns for absorption, stabilisation and redistribution. Auxiliary installations include an extensive addition of rundown and field tankage, as well as increased boiler plant capacity. The purpose of the new construction is to provide facilities for the cracking of fuel oil and gas oil, thereby increasing the overall yield of petrol from crude oil and appreciably improving the quality of both the petrol and fuel oil produced.

Atomic Research

Steps are now being taken by the Federal Government to bring administrative control of Canada's atomic energy plant at Chalk River, Ontario, under direction of the Atomic Energy Control Board, with the National Research Council in charge of the physical operation of the project. It is expected these steps will be completed early in 1947. The Chalk River project was constructed by Defence Industries, Limited, acting as contractors for the Munitions and Supply Department. Defence Industries Limited also was charged with the carrying out of certain operations of the project for war purposes. Scientific information and research was carried out under direction of the National Research Council. The Council's work in connection with the plant will be directed by the Atomic Energy Control Board and a director-general will be appointed to administer the plant. Three directors—for scientific research, engineering and staff and building administration—will assist the director-general. Rigid security regulations, as strict as during the war, will surround the 1600 persons employed in the plant. In addition to the 4,500,000 dollars currently provided for development and expansion of atomic operations at Deep River, the Research Council has a 6,300,000 dollar budget of its own. Prefacing the 29th annual report of the National Research Council, the President, Mr. C. J. Mackenzie, said: "In the physics laboratories one of the main objectives is to develop new and better instruments for the radium industry to assist in the location of radioactive ores and the measurement of these ores and their products. New techniques have been developed for X-ray and radium radiography and research has been directed into the use of X-ray diffraction and electron microscopy to determine the properties of catalysts, pigments, rubber-compounding materials and many other products of interest to industry."

Niagara Frequency

Inauguration of a 60-cycle frequency in the Niagara district to replace the existing 25 cycles would be practical from a technical viewpoint and would involve an expenditure of approximately 200,000,000 dollars covering a period of twenty years. This is the opinion expressed by the Hydro-Electric Power Commission, of Ontario, in an interim report recently submitted to the Ontario Municipal Electric Association executive. The change would not materially increase wholesale rates for power, nor would it entail any increase in retail consumer rates, the report submits. The estimate of the expenditure takes into account the conversion of existing equipment operated by several classifications of consumers and would be effected without any cost to the domestic, rural and commercial customers with equitable adjustment for industry. To keep change-over costs to a minimum the Commission said it would require a special engineering organisation, including field and shop crews, which would make conversions in predetermined areas with dispatch and at a minimum cost. With such an organisation it would be possible to salvage the maximum of material and equipment and reduce to a minimum the inconvenience to consumers. The Southern Ontario or Niagara district runs east from Pickering, which is 20 miles east of Toronto to Windsor and north from Lake Erie to an irregular line stretching from Lake Simcoe to Lake Huron. While the report does not detail a complete plan for conversion, it indicates the initial steps. The des Joachims development on the Ottawa River, now under construction, would be completed for 60-cycle service so as to be available for a change-over programme on a step-by-step basis. In this way the cost up to the time when the des Joachims plant would be loaded was estimated at 45,000,000 dollars. This figure includes all costs incidental to frequency conversion, including the changing of consumer equipment. The Commission emphasised that the information contained in the report was presented as a basis for consideration and discussion.

Infra-Red Detection

A successful attempt was made recently at Shawinigan Falls, Quebec, by three members of the staff of the Heat Laboratory of the National Research Council to locate faulty joints in power transmission lines by means of the heat radiated from the joint. It is well known that bad joints heat up because of their increased electrical resistance, and power companies have been anxious to discover a way of ascertaining whether a joint is warm or not when it is 70ft up in the air, and at a high voltage. Work done on thermal infra-red detection during the war had drawn attention to the feasibility of detecting hot bodies such as ship funnels at a distance, and last winter the Shawinigan Power Company asked the National Research Council if it were possible to detect a hot joint on a transmission line by infra-red methods. As the American military infra-red equipment was not on the market for civilian use at the time the suggestion was made, the test had to be planned using equipment assembled in the National Research Council laboratories.

To make the test, two different "bolometers," or heat detectors, were tried. One, developed during the war by Dr. C. D. Niven and Mr. C. St. Jacques of the Research Council staff, depends on the variation in electrical resistance with heat of a thin film of washed cellophane. The other bolometer used had been captured from the Germans. It had been employed by them in their "donau" equipment for detecting ships off the coast in the dark. The German bolometer depends on the variation with heat of the electrical resistance of a film of antimony. In making a test a bolometer is placed in the focus of a ten-inch front-silvered paraboloid mirror. The heat from the joint is thus focused on the bolometer's sensitive element, and if the temperature of the joint is considerably higher than the temperature of the background sky, then the electrical resistance of the bolometer element changes slightly when the radiation from the joint falls on the element. This very slight change is amplified and is indicated by the movement of the needle in a portable galvanometer.

During the test at Shawinigan Falls both sets of apparatus worked well and agreed in deciding whether a joint was hot or not. Two out of about ten joints examined showed marked heating. It was estimated that the temperatures of these two hot joints were, respectively, about 300 deg. and 400 deg. Fah. A little heat was detected in the cables in an ordinary well loaded transmission line; a good joint on such a line seemed to be actually cooler than the cable. Heat was also detected from an insulator near a carbide plant, but no heat was detected from a knife switch also examined.

Unusual Method of Laying Pipe Line

One of the important steps in the construction of a new pulp and paper mill for Bloedel, Stewart and Welch, Ltd., at Port Alberni, British Columbia, has been the erection of a wood stave aqueduct to convey water from Sproat Lake to the mill. This aqueduct is 5½ miles in length and is designed to carry a maximum of 20 million U.S. gallons every twenty-four hours. Starting with a diameter of 36in, the water line decreases in size to 34in and then to 30in. Pumps have been installed at Sterling Arm on the shore line for the purpose of boosting the water to the greatest height of the line, which is 80ft above the Sprout Lake level. There will be five pumps in this pump-house, each with a capacity of 3400 gallons per minute. Two of these pumps are being put into operation immediately. A third unit will be used for standby purposes and a 200 gallons per minute auxiliary pump is also being installed.

The water pipe line runs from the lake in an easterly direction and crosses the Somass River just north of the pulp mill. At the highest point of the divide, approximately 850ft horizontally from the lake, a surge tank has been built with a 10ft diameter. From this point the water will flow by gravity for 17,000ft, the pipe in this section having a 34in diameter. For the next 10,000ft the diameter is reduced to 30in on account of the land level. Air valves have been installed at high points on the pipe line to release any accumulated air in order to preserve the wood staves by maintaining the pipe full of water at all times.

The laying of the water pipe line across the swift-flowing Somass River was the most difficult project, and here unusual methods were adopted. The original scheme called for the pipe being laid section by section across the river, with the necessary connections being made by a diver. As these diver operations could only have been carried on when tides were favourable at certain hours of the day, the job would not only have been difficult, but also expensive and tedious. It was suggested that the 24in steel pipe could be welded on land, towed to a point where the two ends touched the banks of the river and then sunk into a trench which had been previously dug by a dredger. This plan was accepted by Val Gwythers, chief engineer for Bloedel, Stewart and Welch, Ltd.

Three welders were sent over to Port Alberni from the New Westminster plant and additional crews were secured locally and work was started on the plan. The various sections of the pipe were welded together on a trestle along the river bank. Then the ends of the 600ft tank were closed in order to make the pipe line buoyant when placed in the river. Tugs then took charge and towed the welded pipe line into position. In the meantime a dredger had dug a trench along the river bed and pylons were placed in position to steer the pipes into place. The pipe was floated off the trestles during a high tide. When the pipe was manœuvred into position a pump on a scow was used to partially fill it with water, after which a 3in cock was opened and in 2½ hours the long pipe had sunk into the long-planned position. At one end a coupling was installed under water and Wilfred Hill, head of the Westminster Welding Company, who went to Alberni to supervise the final details, donned a diver's suit to satisfy himself that the connection had been made. The pipe now rests 40ft below low water, safe from ships' anchors.

Rather than dig a tunnel into the lake, an electrically driven pump will be used to bring the water into the intake. This will require a transmission line several miles long. It will cross the Somass River by submerged cable to be laid alongside the water line.

Industrial and Labour Notes

Coal Output

The Ministry of Fuel and Power's official figures concerning coal production in Great Britain in March show that the improved level of output was maintained in spite of the severe weather in the early part of the month. The average weekly production of saleable mined coal was 3,709,500 tons, and of open-cast coal 134,600 tons. The total amount of mined coal lost during the month is estimated at 148,100 tons a week. Of this amount disputes accounted for 9100 tons, accidents, breakdowns and repairs to machinery, 28,100 tons; rail transport difficulties and lack of wagons, 3800 tons, and other causes, 107,100 tons. The provisional figures for April show that in the week-ended April 19th, the output of saleable deep-mined coal was 3,756,400 tons.

The number of wage-earners on colliery books also continues to increase, the total for March averaging 703,400 a week, contrasted with 697,100 in February. The number effectively employed in March was 647,600 a week. Voluntary absenteeism among coal-face workers, estimated at 10·98 per cent, was lower than in February, and there was a slight increase in output per man-shift worked, the March figure being 2·80 tons. The improvement in the manpower situation is continuing, as there were 709,300 wage-earners on colliery books in the week ended April 12th.

Coal consumption in March averaged 3,915,000 tons a week, inland consumption being 3,822,000 tons and overseas shipments and bunkers taking 93,000 tons. The consumption figure for March was below that for February, and dropped still further in the week-ended April 12th, when inland consumption was 3,268,000 tons. The total distributed coal stocks on April 12th were 5,453,900 tons, compared with 7,046,500 tons a year ago.

The Scottish T.U.C.

The Scottish Trades Union Congress was held at St. Andrews last week and, in the course of its business, unanimously passed a resolution approving the Government's production policy. The resolution emphasised the responsibility developing on the trade union movement to ensure the ultimate success of that policy.

Visiting speakers at the Congress included the President of the Board of Trade, Sir Stafford Cripps, who, during his address, said that the essence of social democratic planning was the absence of all compulsion on the individual. Labour, he suggested, was the most difficult of the elements of production. Human beings could not and must not be treated like inanimate materials, and labour could not be ordered and directed, except in the one vital matter of the defence services, where conscription was the necessary and only fair way.

With full employment an accepted policy, Sir Stafford continued, and with it being obviously impossible to do with the existing man-power all that was required, the role of the trade unions had changed and extended, and had assumed greater responsibility. Today, there was a shortage on all sides of persons with the wide economic outlook necessary to tackle the country's problems, and it was essential, Sir Stafford urged, that the trade unions should train and supply more people fitted to understand and cope with planning and managerial problems.

Joint Production Committees

The National Joint Advisory Council, which is composed of representatives of the British Employers' Confederation and the Trades Union Congress, met on Wednesday of last week, and discussed amongst other matters the subject of joint consultation at factory or district level.

A statement issued after the meeting said that in view of the need for maximum production and full employment, the National Joint Advisory Council approved the principle of setting up joint production committees where they did not already exist, for the regular exchange between employers and workers of views on production questions. To this general approval of the principle, the Council added that the joint machinery should be purely voluntary and advisory in character; that it should not deal with questions relating to terms and conditions of employment normally dealt with through the ordinary machinery of joint negotiation; and that it should be left to each industry, through its ordinary negotiating arrangements, to choose the form of machinery best suited to its own particular circumstances, and to decide whether such machinery could best be established at the factory level or cover a wider area.

Both sides of the National Joint Advisory Council agreed that this decision should be brought to the notice of employers' organisations and trade unions.

British Overseas Trade

Exports of United Kingdom goods in the month of March were valued at £82,593,805, which—apart from the shorter month of February—was the lowest figure recorded since September last. On the other hand, the value of imports in March, £130,037,923, was the highest since December, 1925. Re-exports in March amounted to £6,432,400.

Allowing for the rise in prices since 1938, the volume of March exports is estimated at 99 per cent of the 1938 volume. The volume figure for February was 93 per cent, and for January, 112 per cent. It must be remembered, however, that transport and shipment were still being hindered by bad weather in the early part of March, and that the closing down of industrial concerns on account of the electricity crisis in February had an adverse effect upon the supply of goods available for export.

Machinery exports were again at a high rate during March, the total tonnage amounting to 56,669, compared with a monthly average in 1938 of 38,272 tons. The value of machinery exports in March was £13,906,222, or nearly 20 per cent of the total value of manufactured goods exported. Taken generally, the export of vehicles declined during March, the number of private motor cars sent overseas being 6348, compared with 7581 in February. Exports of commercial vehicles, other than tractors, were 1533, which was a little above the February figure. Exports of iron and steel and manufactures thereof amounted to 133,777 tons. In this group the monthly average figure in 1938 was 159,656 tons.

Taking the first quarter of 1947, it may be seen that the value of exports of United Kingdom goods was approximately £249,700,000 a decrease of £16,500,000 on the fourth quarter of 1946. If 100 is reckoned as the export volume figure for 1938, it is estimated that in the first quarter of 1947 the volume figure was 101. In the last quarter of 1946 it was 111.

A Foremen's Charter

In a pamphlet entitled "A National Charter for Supervisors and Technicians," which has been published recently by the Association of Supervisory Staffs, Executives and Technicians, the contention is made that the majority of foremen are being underpaid. The "Charter" demands that all supervisors employed in industrial undertakings should be paid a minimum salary of £500 a year; and the Association says that its aim is to secure a standardised minimum salary with additional bonuses based on length of service and number of staff supervised.

Another claim put forward in the pamphlet is that employers should recognise the status of foremen. In some firms, it is suggested, the prestige of the supervisor has been lowered by shop stewards and higher management reaching decisions without consulting the supervisory staffs. The recognition for which the Association calls, therefore, envisages loyal support of the decisions which supervisors are called upon to make and the action they have to take in the proper execution of their duties; consultation on all matters affecting their work and personal welfare and the work of their departments, and salaries and conditions of service appropriate to their duties and responsibilities.

Joint Consultation on the Railways

The General Secretary of the National Union of Railwaymen has outlined in a recent issue of *The Railway Review*, a plan for discussions between representatives of railwaymen and companies' officers in every department throughout the country, with a view to overcoming many of the difficulties at present experienced in railway working. The N.U.R. it is stated, is prepared to give the fullest co-operation to the achievement of maximum efficiency, and the scheme for joint discussion which it proposes has been accepted by the Minister of Transport in conjunction with the Railway Executive Committee.

After making suggestions as to the appointment of representatives to take part in these joint conferences, the General Secretary of the N.U.R. makes it clear that the meetings held in the ordinary course between the companies' officer and the staff would not be restricted. He says that the general subject of discussion at the joint conferences should be the difficulties under which the railway companies are operating at the present time. The companies' officers could explain the contributory factors, suggest remedies which might be applied, and indicate directions in which the staff could be of particular assistance in bringing about improvement.

The Dock Strike

Since March 24th, approximately 3800 dockers employed in the Port of Glasgow have been on strike as a protest against the dismissal of 500 men on the grounds of redundancy. No progress has been made in discussions on the matter between the Regional Port Director and the Scottish Transport and General Workers' Union. After a meeting of the trade union side of the National Joint Council for the Port Industry on April 16th, the Minister of Transport stated that, if the strikers returned to work any discharged pre-war dockers—estimated to number 204 out of the 500—could be reinstated, and the remaining 296 could be given work, without guarantee, pending inquiry by the National Joint Council into the present labour position at the port.

This Glasgow dispute has now led to serious repercussions in the Port of London, where, on Monday last, over 9000 men belonging to the Stevedores' and Lightermen's Unions struck work in sympathy with the Glasgow dockers. The Transport and General Workers' Union, it should be stated, is opposed to the strike.

The Minister of Labour, Mr. Isaacs, made a statement on the strike on Tuesday last in the House of Commons, saying that the union side of the National Joint Council had met in London that morning to consider the position, and he understood that it had been decided that all the unions should declare whether they abided by the policy of the National Joint Council and accepted its constitution. The Scottish Transport and General Workers' Union was not represented at this meeting. After stressing the seriousness of the dislocation caused by the strike, the Minister emphasised that whatever the facts of the Glasgow dispute, there could be no justification for the stoppage of work in London. It was, he said, a violation of the constitutional machinery of the industry and showed a complete disregard for the effect on the national well-being.

French Engineering News

(From our French Correspondent)

PARIS, April 25th

The aim of the Modernisation Commission for Interior Transport is to achieve traffic equivalent to that of 1929 by the end of 1948, and by 1950 to increase it to 25 per cent above that figure, taking into consideration the fact that the modernisation plan will increase the demand for transport as production in other branches increases. War destruction and pillage of trucks and tools of all kinds has greatly reduced transport facilities. By the end of 1948 it is hoped that French construction, together with foreign imports, will considerably improve the position. On the other hand, the shortage will make increased efficiency of great importance. For example, with only 25,000 carriages, against 35,000 in 1939, the railways will have to carry the same passenger traffic, while goods will be only 10 per cent less than in 1939, with 20 per cent fewer trucks. The S.N.C.F. estimates that certain increases in personnel will be necessary for reconstruction and maintenance purposes. Water traffic, employing only 30,000 persons, will increase its performance with the same personnel. Road transport envisages an increase of 3 per cent in personnel to cope with a 30 per cent traffic increase. Railway materials required by the end of 1948 include 14,000 steam engines and 990 electric locomotives; 130 electric locomotives will be constructed in France, and 1340 steam and 100 diesel locomotives have been ordered abroad. Over 79,000 wagons will be imported, while 1500 carriages and 35,150 wagons will be constructed in France, as well as 180 "autorails" and 350 tractors. To achieve the pre-war waterway tonnage of 3,000,000, 135,000 tons of steel and 4500 workers will be necessary for 2½ years; 50 petrol tankers have also been ordered abroad. By 1949 road vehicles over fourteen years old are hoped to be replaced. Equipment will consist of 260,000 lorries of 2 tons and over, less than fourteen years old, and 15,000 cars; 174,000 lorries of 2 tons and over will be constructed in France; 20,000 lorries have been ordered abroad. It is hoped that tyre production will increase sufficiently to equip the vehicles. In addition to the large electrification programme undertaken by the S.N.C.F., there is to be a 50 per cent increase in lines equipped with automatic signalling, and much extension and transformation of marshalling yards will take place. Finally, main line tracks will be relaid, so that the permitted axle load can be increased to 23 tons. The 1948 railway programme includes 750 railcars and 1250 trailers.

* * *

Many problems of civil and military aviation were considered at the recent French National Aviation Congress. Following the opening of the Congress by Monsieur Maroselli, Minister of Air, the Minister of Transport, Monsieur Jules Moch, spoke of the international character of aviation both from the technical and economic point of view. Other speakers stressed the need to train engineers who would be capable of tackling any task at any time and under any conditions. Just as machines must be perfected beyond the point necessary for any given work, engineers must possess the same quality. It was urged that different firms should set up collective study bureaux, where research could be rationalised. Rigorous inspection and higher standards for machined parts would, it was claimed, reduce costs, and the ability of engineers to determine whether replacement or simply maintenance was necessary would also work to that end.

* * * *

Shortage of miners is still limiting coal output and there is now little hope of an increase. All efforts will have to be concentrated on maintaining the present level, particularly as the 475,000 Germans and 18,000 Polish workers are soon due to leave. Italian immigration has not been as speedy as was hoped, and imports are still comparatively small.

Notes and Memoranda

Rail and Road

RAILWAY RECEIPTS.—Traffic receipts of the British main line railway companies and the London Passenger Transport Board in the four weeks ended March 23rd totalled £21,750,000, compared with £25,717,000 in the corresponding period of 1946.

SNOW CLEARANCE.—The Minister of Transport, in a written reply, says that an investigation is being made into equipment required for snow clearance on the roads. The Minister is not yet in a position to say what types of equipment would be most suitable for use in this country or how many machines it would be justifiable to have available to meet climatic contingencies here.

"LONDON TRANSPORT CARRIED ON."—An account of the London Passenger Transport Board's war-time experiences has just been published in the form of an illustrated booklet entitled "London Transport Carried On." The booklet, which has been written by Charles Graves, tells of undisclosed measures which were taken to prevent the disruption of London's travel services by enemy action, of tasks carried out by L.P.T.B. services, and of the efforts made to restore normal working on underground, bus and tram routes after dislocation had been caused through bomb damage. A copy of the booklet has been distributed to every member of the L.P.T.B. staff.

RADIO COMMUNICATION ON RAILWAYS.—The Assistant Postmaster-General was asked in the House of Commons last week when he would be able to allocate suitable wavelengths to the railways to enable them to carry out preliminary trials and further research into the prospects of adapting radio communication for railway purposes. Mr. Michael Stewart, Vice-Chamberlain of the Household, who replied, said that it was hoped to make some wavelengths available to the railway companies during the next few weeks. The wavelengths would be liable to alteration, however, in the light of the conclusions of an international radio communication conference which was to be held during the summer.

Air and Water

NORWEGIAN WHALING FACTORY.—A whaling factory ship of 25,000 tons, the "Kosmos III," was recently launched from the Götaverken shipyard, Gothenburg, Sweden, where she is building for Norwegian owners. The ship is claimed to be the largest of its kind so far built in Scandinavia.

ORE-PROSPECTING BY HELICOPTER.—According to *The Anglo-Swedish Review*, a new method for ore-prospecting from the air with a helicopter has been evolved by a Swedish engineer, Hans Lundberg, of Toronto, Canada. It is reported that in an area normally requiring two and a half months to explore and map out magnetically from the ground, exactly one hour's flying time sufficed with the Lundberg method. His map corresponded in all essentials with one previously made on the ground. The method, it is claimed, provides all the data necessary for continued investigations.

R. N. STOKER MECHANICS.—Stokers in the Royal Navy are to be renamed "Stoker Mechanics," a change which has been decided upon after a good deal of discussion. In point of fact, the engine-room rating has for a long time been a mechanic, operating not only the oil-fired boilers but diesel machinery, evaporators and other auxiliaries such as the arrester gear on the flight deck of an aircraft carrier. Nevertheless, the word "stoker" has such strong Naval associations, dating back to the middle of the last century, and its complete abolition was not generally favoured. It was therefore agreed to add the description "mechanic" to show the kind of job these ratings do and retain "stoker" to indicate the engine-room department and to distinguish them from air mechanics. It is interesting to recall that in the days when stokers did stoke, an enormous number was required to do the job which machinery does to-day. H.M.S. "Lion," built as a battle cruiser in 1909, and developing 70,000 shaft horsepower, carried no less than 600 stoker ratings, and burned about 1200 tons of coal a day at full power. H.M.S. "King George V," a battleship completed in 1940, and developing some 110,000 shaft horsepower has only 250 stoker mechanic ratings aboard. She is, of course, entirely driven by oil-fuel, With modern machinery, the weight of oil required to produce 1 h.p. is about half that of the coal which was required to produce the same power in H.M.S. "Lion."

Miscellanea

THE RADIOACTIVE SUBSTANCES BILL.—In the House of Lords, on April 24th, the Lord Privy Seal, Lord Inman, presented a Bill making provision respecting radio-active substances and certain apparatus for producing radium. Under the Bill the manufacture, import, use and possession of radioactive substances are to be subject to licence, and there is also provision for regulating the disposal of radioactive waste products.

SILICON METAL.—The Minister of Supply has announced that he will cease to trade in silicon metal after June 30th. Orders for metal to be delivered from July 1st onwards should be placed with the usual trade suppliers. With the agreement of the President of the Board of Trade, individual licences will be issued for imports of silicon metal and applications for licences should be submitted in the usual manner to the Import Licensing Department, Board of Trade, 189, Regent Street, London, W.1. Licences will not be issued for the re-export of silicon metal.

TIMBER RESEARCH IN BUILDING.—An exhibition on Timber Research in Building is now being held at the Royal Institute of British Architects, 66, Portland Place, W.1. It has been arranged by the Forest Products Research Laboratory of the D.S.I.R. The primary object of the exhibition is to show architects and builders how to make the most efficient and therefore most economical use of timber. It is, however, of broad and general interest, there being twelve sections dealing with different aspects of the subject, including preservation, death watch beetle, dry rot and other fungus decays, seasoning, bending, composite wood and machining. The exhibition will remain open on weekdays from 10 a.m. to 5.30 p.m. until May 10th.

AN "INDUSTRIAL WALES" EXHIBITION.—It is announced that the Industrial Association of Wales and Monmouthshire has arranged an "Industrial Wales" Exhibition, which will be held in the Empire Hall of Olympia from August 28th to September 13th, this Autumn. Some 150,000 square feet of space will be available for the large variety of goods which Wales now produces. Among other exhibits will be steel and wood furniture, plastic and rubber products, hollow-ware, clocks and watches, precision products, household equipment, gas and electrical appliances, diamond tools, motor bodies, prefabricated houses, and industrial chemicals. Nearly 20,000 square feet will be occupied by heavy machinery, tin-plate and steel exhibits, the traditional products of Wales. The National Coal Board and the Ministry of Fuel and Power have collaborated in a joint exposition of the coal industry and the Board of Trade is showing the steps which have led to the recent astonishing development of Wales as an industrial producing area. Fuller details of the exhibition can be obtained from the Exhibition Offices at 3, Castle Street, Cardiff.

THE JUNIOR INSTITUTION OF ENGINEERS.—The sixty-third anniversary of the foundation of the Junior Institution of Engineers was celebrated by a dinner which was held in London on Friday, April 25th. The President of the Institution, Major-General A. W. Sproull, was in the chair and a large number of members and guests were present. Following the dinner, the toast of "The Institution" was proposed by Mr. V. Z. de Ferranti, who congratulated the Institution on the width of its interests and the lack of formality for which its meetings were so well known. In replying, Mr. Rex Wailes said it was pleasing to note the growth and increasing number of local sections which were coming into being. Speaking on the subject of inspection and industry, Mr. A. Woodburn, the Joint Parliamentary Secretary to the Ministry of Supply, said that the Government will be spending considerable sums of money on scientific and research development. With the present man-power shortage it is essential that the best possible use should be made of all available labour, and to this end we must turn to engineering science and skill to solve our problems. In replying, Major-General Sproull pointed out that Britain had led the world in engineering development in the past, and that the future was hers for the asking. During the war our scientists and engineers had proved by their work that they were second to none, and now was the time to ensure the future and substantiate our reputation for producing the best that could be obtained in the world. In this direction, the speaker said, good and thorough inspection was the keynote to efficient production and it must be kept always to the highest standard.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

"Britain's Best" Engineering and Metalcraft Exhibition

Monday, May 12th to Friday, May 23rd.—London, Royal Horticultural Hall, Westminster, S.W.1.

British Industries Fair

Monday, May 5th, to Friday, May 16th.—London, Olympia and Earls Court; Birmingham, Engineering and Hardware Section, Castle Bromwich, Birmingham.

Illuminating Engineering Society

Friday, May 9th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham. "The Physical Nature of Light," J. Cull. 6 p.m.

Tuesday, May 13th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. Annual general meeting. 6 p.m.

Institute of Economic Engineering

Friday, May 16th.—Cowdray Hall, W.1. "Practical Problems of Production Control." A. W. Willsmore. 7 p.m.

Institute of Fuel

Wednesday, May 28th.—Geological Society, Burlington House, Piccadilly, W.1. "Combustion and Combustion Equipment for Gas Turbines," E. A. Watson and J. S. Clarke. 2.30 p.m.

Institute of Marine Engineers

Tuesday, May 13th.—85, The Minories, E.C.3. "Developments in Machinery of Cross-Channel Vessels," E. L. Denny and G. E. Barr. 5.30 p.m.

Institute of Metals

Wednesday, May 21st.—Institution of Civil Engineers, Great George Street, S.W.1. "Metallurgical Problems Involved in the Generation of Useful Power from Atomic Energy," Sir Wallace Akers. 6 p.m.

Institution of Chemical Engineers

Tuesday, May 6th.—Geological Society, Burlington House, Piccadilly, W.1. "The Re-use of Waste Waters from Industrial Processes," B. A. Southgate. 2.15 p.m.

Institution of Civil Engineers

Tuesday, May 6th.—Great George Street, S.W.1. "The Use of Plant in Soil Stabilisation," C. F. Armstrong. 5.30 p.m.

Tuesday, May 13th.—SOUTH WALES ASSOCIATION: Institute of Engineers, Park Place, Cardiff. "Civil Engineering Aspects of Naval Harbours and Bases." Sir Arthur Whitaker. 6 p.m.

Institution of Electrical Engineers

To-day, May 2nd.—N.-EASTERN STUDENTS' SECTION: County Hotel, Newcastle-on-Tyne. Annual general meeting and annual dinner. 6.45 p.m.

Saturday, May 3rd.—N. MIDLAND STUDENTS: Visit to the Mexborough Generating Station of the Yorkshire Electric Power Company, at Grey's Bridge, Mexborough. 2.30 p.m.

Monday, May 5th.—S. MIDLAND CENTRE: James Watt Institute, Great Charles Street, Birmingham. "Industrial Application of Electronic Techniques," H. A. Thomas. 6 p.m.

Tuesday, May 6th.—N. MIDLAND CENTRE: Corporation Electricity Department, Whitehall Road, Leeds. "High Speed Photography," G. A. Jones. 6 p.m.

Wednesday, May 7th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. "Accurate Measurement of the Group Velocity of Radio Waves in the Atmosphere, Using Radar Technique," R. A. Smith, E. Franklin and F. B. Whiting. 5.30 p.m.

Tuesday, May 13th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "Future Trend of Component Design for the Services." 5.30 p.m.

Saturday, May 17th.—N. MIDLAND STUDENTS: City Electricity Department, Whitehall Road, Leeds, 1. Annual general meeting and films afternoon. 2.30 p.m.

Institution of Heating and Ventilating Engineers

Tuesday, May 6th.—LONDON ASSOCIATE MEMBERS AND GRADUATES' SECTION: Junior Institution of Engineers, 39, Victoria Street, S.W.1. "Hot Water Supply by Electricity," J. I. Bernard. 6 p.m.

Institution of Production Engineers

Thursday, May 8th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "A Practical Approach of Research to Industry," H. W. Hobbs. 6.30 p.m.

Saturday, May 10th.—YORKSHIRE GRADUATES: Great Northern Hotel, Leeds. Annual general meeting and Luncheon. 1 p.m.

Monday, May 19th.—DERBY SUB-SECTION: Art School, Green Lane, Derby. "Lay-Out of Factory and Plant for Efficient Production," S. Gilbert. 6.45 p.m.

Saturday, May 31st.—YORKSHIRE GRADUATES: Visit to David Brown Tractors, Ltd., Meltham. 2.30 p.m.

Iron and Steel Institute

Wednesday, May 14th.—Institution of Civil Engineers, Great George Street, S.W.1. Second Hatfield Memorial Lecture. "Steels for Use at Elevated Temperatures," Dr. C. Sykes. 8.30 p.m.

Wednesday to Friday, May 14th to 16th—Annual Meeting in London. For programme, see page 367, April 25th.

Junior Institution of Engineers

To-day, May 2nd.—39, Victoria Street, S.W.1. "The Post Mill," Rex Wailes. 6.30 p.m.

Friday, May 9th.—Institution of Civil Engineers, Great George Street, S.W.1. "The Synthesis of Oil from Coal by the Fischer-Tropsche Process," C. C. Hall. 6.30 p.m.

Keighley Association of Engineers

Saturday, May 3rd.—Visit to Waite and Saville, Ltd., Otley. 2.15 p.m.

London Association of Engineers

Saturday, May 3rd.—Charing Cross Hotel, W.C.2. "Precision Measuring Instruments," C. O. Tayler-son. 6.30 p.m.

Royal Institution of Chartered Surveyors

Monday, May 5th.—12, Great George Street, S.W.1. "Effects on Landed Property of Income Tax, with Special Reference to the Income Tax Act, 1945," W. Walker Watson. 5.30 p.m.

Sheffield Metallurgical Association

Tuesday, May 6th.—198, West Street, Sheffield, 1. "Heat-Resisting Steels," D. A. Oliver. 6.30 p.m.

Society of Chemical Industry

Thursday, May 15th.—ROAD AND BUILDING MATERIALS GROUP: Gas Industry House, 1, Grosvenor Place, S.W.1. "Sawdust Cement and Other Sawdust Building Products," Dr. T. W. Parker. 6 p.m.

Society of Engineers

Monday, May 5th.—Geological Society, Burlington House, Piccadilly, W.1. "The Engineer and the Law," C. L. Boucher. 5 p.m.

Stephenson Locomotive Society

Saturday, May 24th.—SCOTTISH CENTRE: Visit to North British Locomotive Co., Hyde Park, Glasgow. 2.30 p.m.—NORTH-EASTERN CENTRE: Visit to Dunston-on-Tyne Power Station. 2.30 p.m.

Saturday, May 31st.—Visit to Crewe Works and Sheds, L.M.S.R. 9.30 a.m. and 2.30 p.m.

Women's Engineering Society

Thursday, May 8th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester. "Capacitors: Their Manufacture and Testing," Miss W. Hackett. 6.30 p.m.

Friday, May 16th.—35, Grosvenor Place, S.W.1. "Women in Post-War Engineering." 7 p.m.

Personal and Business

MR. F. WILLIAMS has been appointed a director of Markham and Co., Ltd.

E. H. JONES (MACHINE TOOLS), LTD., is opening new Midland showrooms at 72–78, Wrentham Street, Birmingham, 5.

MR. G. R. GOODALL has been appointed an electrical and mechanical engineer in the Public Works Department, Uganda.

THE LONDON PASSENGER TRANSPORT BOARD announces the appointment of Mr. T. W. Towers as operating manager, trams and trolleybuses.

MR. C. R. BALCH has been appointed manager of the Cardiff plant sales division of Crompton Parkinson, Ltd., in succession to Mr. D. Nield, who has retired.

BENNIE LIFTS, LTD., states that its sheet metal department is now situated at Glasgow Terrace, 111, Grosvenor Road, London, S.W.1 (telephone, Victoria 5914). Mr. C. A. McAuliffe is manager of the department.

THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, LTD., announces the following appointments: Major L. H. Peter, M.I.E.E., chief development engineer; Mr. L. E. Thompson, chief electrical engineer; Mr. K. H. Leech, chief design engineer; Mr. N. G. Cadman, chief brake engineer.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY announces the following appointments: Mr. C. Haysey, district engineer, Leeds; Mr. G. F. Kent, district engineer, Barrow; Mr. G. H. F. Lutter, assistant to district engineer, St. Pancras, and Mr. G. F. C. Goodacre, assistant to mining engineer, chief civil engineer's department, Derby.

BRITISH MESSIER, LTD. is the title of a new company formed to develop and market aeroplane undercarriage, hydraulic, pneumatic and electrical equipment, based on the French Messier designs. The Bristol Aeroplane Company, Ltd., is interested in the new company, the directors of which are Mr. W. R. Verdon Smith, Mr. L. S. Armandias, Air Commodore F. R. Banks, and Mr. H. G. Conway. Mr. W. Masterton is the secretary, and the address of British Messier Ltd., is at Cheltenham Road East, Gloucester.

Contracts

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY has placed an order with Richard Dunston, Ltd., Thorne, near Doncaster, for a new twin-screw diesel tug for use in Wyre docks, Fleetwood, in replacement of an old steam-driven tug. The new vessel will have an overall length of 75ft, breadth 16ft, depth 9ft, and will be fitted with two Ruston and Hornsby six-cylinder VCBM engines, having oil-operated reverse reduction gear.

Reports on German Industry

Limited numbers of copies of the reports of Intelligence Objectives Sub-Committees on German Industry listed below can be obtained from H.M. Stationery Office at the prices stated.

No. of report.	Title.	Post free.
B.I.O.S.:		
710	Manufacture of Biolase (Starch-hydrolising Enzyme) at Kalle and Co. (I.G. Farben A.G.), Wiesbaden, Biebrich	1 1
716	German Steel Foundries, includes Information on Silicosis Preventive Measures	6 8
719	Interview with Professor Otto Bayer, formerly Member of the Directorate and Head of the Scientific Laboratories of the I.G. Farbenindustrie, Leverkusen: Chemistry of Isocyanates and the New Polyisocyanates	1 1
741	Zellstofffabrik A.G., Mannheim: Recovery and Dehydration of Alcohol from Spruce Wood Waste Sulphite Liquor	1 1
743	Manufacture of Cyclohexanol, Cyclohexanone, Cycloketone Resins at I.G. Ludwigshafen	1 7
757	Manufacture of Ethylene Cyanhydrin at I.G. Ludwigshafen	0 7
F.I.A.T.:		
92	German Processing of Fats, Oils and Oil Seeds	10 9
107	Cold-Ray Pasteurisation of Milk	1 7
215	Fumigants Distributed by Degesch, A.G. Weissfrauenstrasse 9, Frankfurt	0 7
230	Metallurgical Practice in the Precision Cutting Tool and Gauge Plants in Germany	4 8
394	Modified and Improved Wood in Western Germany	4 8
581	Beier Infinitely Variable Speed Friction Drive Transmission	2 1
591	Hanomag Diesel Engines for Passenger Cars, Tractors and Trucks	1 8
686	Casting Methods for Aluminium and Aluminium Alloy Billets	1 7
713	Cellulose Acetate Manufacture at Schering A.G., Berlin	1 7
721	The Agfacolour Negative-Positive Method for Professional Motion Pictures	3 2
742	Surgical Instrument Industry in Tuttlingen, Germany	0 7
J.I.O.A.:		
13	Photo-Mapping and Map Reproduction	5 2
64	Instructions for the Preparation of the Dyestuffs Filterblaugrun Spritlosich and Filterblaugrun Wasserloslich: Report in German	1 1
66	Glossary of some German Names for Chemical Products Used in the Paint, Varnish and Lacquer Industry	1 7
C.I.O.S.: XXXIII–36	Design of Turbo-Generators Built for German Navy	9 3
B.I.O.S.:		
435	Ozalid Light-Sensitive Materials: Kalle and Co., Wiesbaden-Biebrich (I.G. Farbenindustrie A.G.)	1 1
479	Some Aspects of the German Peat Industry	2 2
609	Non-Destructive Testing of Materials	2 1
674	The German Electrically Welded Steel Tube Industry	4 2
740	G. F. Boehringer und Soehne, Mannheim-Waldhof: Commercial Organic Solvent Production	1 1
748	Manufacture of Fatty Acids by Oxidation of Paraffins, Hydrogenation of the Fatty Acids at I.G. Ludwigshafen-Oppau	2 1
749	Pilot Plant at I.G. Hoechst on the Manufacture of Diketene from Acetic Acid	0 7
750	Manufacture of Monomeric Styrene at I.G. Ludwigshafen	1 1
753	Manufacture of Phthalic Anhydride and Phthalates at I.G. Ludwigshafen	2 1
754	Hydrocyanic Acid: I.G. Oppau and Ludwigshafen	1 1
759	Pilot Plant for Manufacture of Acrylonitrile at I.G. Oppau	0 7

During the past few months amendments and addenda to the following reports have been issued and made available at H.M. Stationery Office sales offices:—C.I.O.S. Nos. XXVIII–18, XXXIII–23; B.I.O.S. Nos. 35, 135, 199, 217, 307, 340, 345, 363, 405, 422, 423, 429, 438, 450, 468, 507, 572, 591, 773; F.I.A.T. No. 273.

An almost complete set of German patent specifications, accepted by the Berlin Patent Office during the war, has been secured for the United Kingdom. The specifications, for which either annual or weekly subject-matter and name indices are available, can be seen by the public at the Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.2. Both the indices and the specifications are in German. Photographic copies of any specification and drawings may be obtained at the rate of 6d. per page.